SCIENTIFIC AMERICAN

No. SUPPLEMENT 338

Scientific American Supplement. Vol. XIII., No. 338. Scientific American, established 1845.

NEW YORK, JUNE 24, 1882.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

OPENING OF THE ST. GOTHARD TUNNEL.—THE SWISS ENTRANCE TO THE TUNNEL NEAR GOESCHENEN.

OPENING OF THE ST. GOTHARD TUNNEL.—THE ITALIAN APPROACH TO THE TUNNEL NEAR AIROLO—THE ZIGZAGS SHOW THE OLD CARRIAGE ROAD.

THE ST. GOTHARD TUNNEL.

WITH four days of festivity during the last week in May, 1882, was inaugurated the railway through the Alps, under the St. Gothard Pass. Begun eleven years ago, the great subway under the Kastelhorn was pierced from Göschenen to Airolo by the 29th of February, 1880, but though the headings of the bore met on that date, it has required more than two years to complete the minor works.

Dynamite and compressed air drills were the principal appliances used by the engineers, and by these means they were enabled to progress at an average rate of from 20 ft. to 24 ft. per day. The rocks through which they dug their way were for the most part a hard granitic gneiss, much fissured, and generally free from water. That which gave as much trouble as any was a layer of plastic clay. The difficulties of ventilation formed another serious obstacle to the progress of the work. The navvies were mainly drawn from Italy; five shillings a day for eight hours' work in a vitiated atmosphere, rarely below 100 degrees, half-naked, and often in water, being insufficient to attract English shovelmen. Congestion of the brain, irregular action of the heart, anæmia, and other more obscure diseases were the common results of prolonged labor in the tunnel. A deathly pallor characterized their faces. Many stooped like old men, and often in coming out of the tunnel they had to support their tottering steps with a staff. Altogether, out of the 4,000 workmen who have been engaged in its construction, between sixty and seventy have lost their lives.

The length of the great tunnel is nine miles and 468 yards, the *maximum* width 26 ft. 3 in., and the height to the crown of the arch 19 ft. 8 in. At Göschenen the rails are 3,638 ft., and at Airolo 3,756 ft. above the sea. The well-known Devil's Bridge on the St. Gothard road, and the western boundary of the village of Andermatt, are almost exactly above the great tunnel. There are in the twenty miles of which the line through the mountain chain consists several smaller ones three or four miles long, as well as many galleries and bridge like cuttings. Among these minor borings the "spiral tunnels" are interesting features. When a considerable rise is required the line is run into the side of the mountain, and the tunnel being constructed with a sharp curve and steep gradient, the line at a much higher level crosses its former course. From the point where the St. Gothard Railway commences, at Immensee on the Lake of Zug, to where it joins the Italian system, it is 152 miles long, and the nature of the country traversed may be gathered from the fact that 17 per cent. of its entire mileage is through the fifty-nine tunnels which give it passage. For the greater part of the way it will run on single lines; but arrangements have been made for crossing the trains at every station, and for widening the tunnels, if necessary, without stopping the traffic. The cost has been about £7,000,000.—*Building News.*

For a more full history of the St. Gothard Tunnel, with illustrations of details machinery used in construction, etc., see SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 26, 63, 225, 226, 227.

THE BERLIN METROPOLITAN RAILWAY.

By WILLIAM BIRD.

AT a recent meeting of the Civil and Mechanical Engineers' Society, London, Mr. Wm. Bird read a paper as follows:

The marvelous increase in the size and population of the large cities of the civilized world since the commencement of the present century, has necessitated the adoption of increased facilities of communication for the purpose of relieving the congestion of traffic in the streets, and enabling the inhabitants to spread themselves over a large area. This, it is now universally recognized, can only be effectually accomplished by carrying railways through and into the center of large cities; for tramways, and other means of transport, are scarcely suited for the conveyance of large masses of people. Hence, the development of metropolitan railways, the latest addition to which is the Berlin Metropolitan Railway, which, commenced in 1875, was opened in February of this year for local traffic.

The enterprise, which in 1875 was reconstituted as a limited company, the shareholders being the State, the interested private railway companies, and the Deutsche Eisenbahn-Bau-Gesellschaft, has since 1878 become absolute State property, the private railway companies interested in the scheme having been granted, however, running powers over the line.

The line as it has been built starts from the old Frankfurt (now Schlesische) railway station at the east of the town, runs through a densely populated neighborhood until it reaches the river Spree. It then follows the course of the river for about 660 yards, until it reaches the Jannowitz Bridge, thereby narrowing the stream, which at this point is much wider than desirable. From here it makes a sharp bend into the Königs-Graben, an old canal which, useless for navigation purposes, and in a sanitary sense most objectionable, has been stopped up, thus conferring an inestimable benefit on the town, and completely altering the aspect of the neighborhood. The line then follows the Königs-Graben for a distance of one and a quarter miles, thus obtaining the land acquired at this point at a comparatively low cost, till it reaches the Monbijou Palace, crossing the Spree at the Museum Island on two handsome stone bridges. Passing through the most populous part of the town, it reaches the Friedrichsstrasse close to the celebrated boulevard, Unter den Linden. It again crosses the Spree near here, and, passing over the rails of the Lehrte Railway Station, crosses the Spree again for the last time near the Bellevue Park. It then enters the celebrated park of Berlin—the so-called Thiergarten—passes close to the Zoological Gardens, and terminates near Charlottenburg, the most important and populous suburb of Berlin. The total length of the line is about 7·5 miles, with nine stations, namely: the Eastern terminus or Schlesische station, the Jannowitz bridge station, the Königsbrücke or Alexander Platz station, the Royal Exchange station, the Friedrichsstrasse station, close to the celebrated boulevard, Unter den Linden; the Lehrte station, the Bellevue or Moabit station, the Zoological Gardens station, and the Western terminus or Charlottenburg station. Having thus shortly described the route of the line, I will now attempt to point out its characteristic features. The Berlin Metropolitan Railway has been built to serve two distinct purposes. First to afford increased facilities of intercommunication between different parts of the town, its adjoining suburbs, and the Ring Railway. Second, to connect the east and west lines of railway terminating in Berlin, thus enabling passengers coming from a distance to continue their journey eastward or westward, without loss of time or the necessity of making use of cabs or other conveyances to proceed from one station to the other.

These two different purposes have been kept entirely separate one from the other, and, in consequence, two distinct systems of traffic have been adopted—namely, local and through traffic. This has been effected in the following manner. The Metropolitan Railway has been constructed to carry four lines of rails, the two lines on the north side being devoted solely to the local traffic, the two on the south side to through traffic. Both systems run parallel to each other. The two local lines branch off at the Schlesische Railway station to the north and south, and connect the Metropolitan Railway with the Ring Railway. The same occurs at the western terminus of the line at Charlottenburg. By this means two complete circles are formed, the one a north the other a south circle. The local trains will, starting from the Schlesische Railway station, run over the Metropolitan Railway to Charlottenburg; from there, over the northern half of the Ring Railway back to the Schlesische Railway station, and *vice versa*, thus forming the northern circuit. Starting again from the Schlesische Rail way station trains will run over the Metropolitan Railway to Charlottenburg, from there over the southern half of the Ring Railway back to the starting point and *vice versa*, thus forming the southern circuit. I need not point out to you that this plan presents greater advantages than if trains were run in a complete circle round the Ring Railway, and connected by trains running backward and forward between the Schlesische Railway station and Charlottenburg. I will only remark that the northern part of Berlin is much more thickly populated than its southern part, and demands, therefore, greater train accommodation, and by the adoption of two circles twice as many trains can be run through the northern district than through the southern, which could hardly be accomplished by any other arrangement. Besides these circle trains, local trains on the Metropolitan Railway will be run between the two termini, according to requirements, and also from outlying suburbs, such as Potsdam, Spandau, Erkner, etc. At present trains are to be run only every ten minutes, but eventually every five minutes. So much for the arrangement of the local traffic. The through traffic will be worked as follows:

Trains arriving from the west, instead of stopping at the western terminus, Charlottenburg, will run over the Metropolitan Railway to the eastern terminus, or Schlesische Railway station, stopping only at the four stations, Charlottenburg, Friedrichsstrasse, Alexander-Platz, and Schlesische station; those trains arriving from the east will run in the opposite direction from the Schlesische Railway station to Charlottenburg, stopping at the same stations, thus connecting the different lines of railway, and also enabling passengers to alight in different parts of the town. For the through traffic the Metropolitan Railway may be said to form one large extended central station. The lines of the Metropolitan Railway are so arranged that not one of them crosses the other on the same level. Of the nine stations of the Metropolitan Railway, all nine have been designed to accommodate the local traffic; four only, however, have been constructed to accommodate both local and through traffic, these being Charlottenburg, Friedrichsstrasse, Alexander-Platz, and Schlesische Railway station. These four last-mentioned stations are considerably larger than the others, requiring as they do large waiting-rooms, booking-offices for passengers and baggage, cabstands, etc., whereas the size of the remaining five has been reduced to a minimum.

Turning now to the constructive features of the line. The town of Berlin being situated but a few feet above the level of the river Spree, an underground railway was out of the question, as was also a railway on a level with the streets, an overhead railway had consequently to be resorted to. For obvious reasons, an embankment could not be adopted, so that the characteristic feature of the line is that of a viaduct. The viaduct consists mainly of brick arches and piers, the level of the rails being about 24 feet 6 inches above the level of the streets. The length of the spans varies from 26 feet 3 inches to 49 feet 3 inches, the arches are segmental, with a rise of 1-6th to 1-3½ of the span, and with an average height of 19 feet 8 inches from the level of the streets to the intrados. The width of the viaduct, measured along the piers, is 47 feet 6 inches, but, by stone coping, this is increased to 51 feet at the top of the platform. The two center lines are 13 feet 8 inches apart from center to center, the outer ones 11 feet 6 inches from center to center, the gauge being the usual 4 feet 8½ inches. The arches having been built with the view of being let out for various purposes, large openings have been made in most piers to facilitate communication between the same. The span of the arches varies with the depth of the foundations, the deeper the latter the greater the span. The surface water is drained off by vertical shafts through the piers. The spandrels are built up with smaller arches, for the purpose of economy, and easier inspection of the arches. Concrete is spread over these smaller arches and the whole covered by a layer of asphalt and the ballast. In the center of the viaduct a small canal, 1 foot 8 inches wide, has been sunk for the protection of the plate layers and other inspecting officials, and footpaths are arranged on both sides. The most interesting part of the viaduct is that in the Spree, about 660 yards long, which consists of brick arches 49 feet 3 inches span, 14 feet 1 inch rise, and piers built upon caissons. I may remark that the arches are not built, as in England, in concentric rings, but in bond, like an ordinary upright wall.

Foundations.—The latter are either (1) direct; (2) on concrete; (3) on concrete, between sheet piling; (4) on piles; (5) on stone wells or caissons. The two first require no further comment. The following remarks may be of interest as illustrating the continental way of treating the three last mentioned descriptions of foundations: In the case of piles, the same are on an average 33 feet long, about 3 feet apart, connected transversely and longitudinally by strong sills, and the whole covered with a stout planking. The piles in each outer row are driven in at an inclination of 1 in 12. In the case of concrete between sheet piling, the latter is driven below the eventful depth of the foundation, the irregularities between the sheet piling carefully calked; the stuff between the sheet piling is then dredged out and cement concrete sunk under water by means of large cylinders. This concrete is left to harden; the remaining few feet of water is then pumped out, and the pier built up. By this means the necessity of a coffer dam is avoided. In the case of brick wells or caissons, the walls of the well are built up two bricks thick on an oak frame, the whole being tied together with strong iron bolts. The wells have a square section of about 18 feet, and are battered on all four sides inside. The same are sunk by dredging out the earth inside and built up as they are sunk. They are then filled up under water to a height of 6 feet with cement concrete, this is left to harden; the water is then pumped out and the remaining 17 feet filled in with brickwork. The caissons are connected at the top by small segmental arches, and on top of the whole the piers or abutments are then built up in the usual way.

Stone Bridges.—There are only two stone bridges on the whole line, one of 78 feet 8 inches span over the Schiffahrts Canal in the Thiergarten, which presents no further features of interest. The other over the Spree at the Museums Island consists of two spans of 55 feet 8 inches, and 59 feet, separated by a pier 13 feet 2 inches thick, and crossing the river at an angle of 35 degrees. In consequence of this considerable skew the bridge has been built in eleven ribs on the square, tied together at the crown by iron bolts. The width of the bridge is 57 feet instead of 51 feet, as it is intended later on to build a second viaduct on top of that of the Berlin Metropolitan Railway. Wherever the viaduct is visible from the streets, great attention has been paid to its architectural development.

In all cases where streets are crossed iron bridges are employed. Of these there are sixty-four in all, with a total length of three quarters of a mile of iron structure and spans varying from 55 feet to 164 feet. The Berlin police regulations require a clear height of 14 feet 5¼ inches from roadway to underside of bridge. These bridges may be classed as follows:

I. Ordinary plate girder bridges. Of these there are six in number, which call for no further remark.

II. Continuous plate girder bridges. Forty-four bridges have been built of this type, forty-two of which are divided by two rows of cast or wrought iron columns into three spans, and two by one row of columns into two spans. The lower booms of these girders are bent down in elliptical curves on to the capitals of the columns, thus presenting nearly the appearance of an arched bridge. The columns are provided with upper and lower ball hinges. The girders are anchored by means of strong bolts to the abutments, the object being to reduce the shocks which so militate against the use of continuous girders to a minimum. These bridges were built up in two or three parts and then connected after erection.

III. Lattice girder bridges. In all there are seven bridges of this type, five of which have horizontal upper and lower booms, and lattice work consisting of tension diagonals and verticals. The bridge over the Spree at Bellevue, which crosses the river at an angle of 45 deg., consists of three spans of about 85 feet each, and two smaller side spans. In consequence of the oblique angle, the two mid-stream piers were not built as one continuous structure, but consist each of four cylindrical granite piers about 4 feet 6 inches diameter, which carry the four principal girders, forming the bridge. The cross girders rest on the top booms of the principals. The distance from center to center of each principal is 12 feet 1 inch. The lattice work consists of isosceles triangles, the base of each being about 12 feet 1 inch, and the height 9 feet 1 inch. Over the piers the girders fit one within the other, but are not rigidly connected, thus giving the whole bridge the appearance of a light continuous girder. The left sided bearing is fixed; the right sided one consists of a pendulum bearing so that the whole of the difference in length caused by change of temperature is compensated on this one side. The two mid stream piers rest on stone caissons; the land piers are built respectively on piles and on concrete, between sheet piling. The bridge over the Humboldt Harbor, consisting of seven spans of 101 feet 8 inches, deserves mention on account of its peculiar construction. It consists of two trusses, the smaller of which hangs within the larger, the upper and lower booms of both trusses being riveted together and the smaller truss connected besides to the larger by diagonals. The girder is divided into four fields of about 24 feet 8 inches in width, and 12 feet 3 inches high, stiffened by vertical posts. The cross girders rest on top of the upper booms. The upper and lower booms are built up of 2 respectively 4 [irons strengthened by plates, the verticals consist of 4 < irons. The bearings are constructed as ball hinges.

IV. Trussed arched bridges. Seven bridges have been built on this type. The section of upper boom and arch is ⊥ shape to simplify the connection of the diagonals of the lattice work, these latter have a ⌶ section. The plates joining the lattice work to the upper boom and the arch have been kept as small as possible so as not to interfere with the outline of the arch. At the crown of the arch the lattice work is replaced by a plate. The lattice work consists of double or single diagonals.

V. Elastic-arched bridges, or single diagonals, consisting of the arch and the upper horizontal girder connected by vertical posts. The section of the arch in this case is I-shape. Of this description only three bridges have been built.

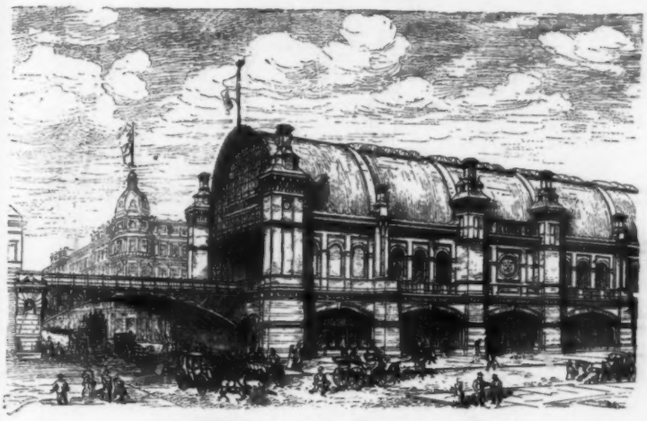
The following general remarks apply to all five descriptions of iron bridges: The superstructure is constructed on two systems. The one consisting of small trough girders filled with gravel placed on top of the cross girders was soon abandoned on account of the difficulties experienced where the lines had to be widened out, and in the approaches to the stations in the introduction of switches and crossings. In its place a platform constructed of buckle plates, over which from 10 to 12 inches of gravel is spread, was adopted. These buckle plates are supported by the cross and small longitudinal girders to which they are riveted; they are about 4 feet 9 inches square and ¼ inch thick. Of course this construction increases somewhat the weight of the bridges, but the many other advantages it presents, such as simplifying the laying of the permanent way, deadening the noise, etc., decided on its adoption. The cross and small longitudinal girders consist principally of rolled girders, strengthened by riveted plates, but in some cases of built-up girders. The cross girders are constructed as continuous girders, being supported at one or two points by trusses. Two sideways, and one in the center, were provided for, similar to those on the brick viaduct. The surface water was carried off by means of specially constructed channels.

The Permanent Way.—The system of permanent way employed on the Berlin Metropolitan Railway is that of Haarman, similar to that of Hilf. It consists of inverted trough-shaped longitudinal iron sleepers, with a broad base on the ballast, on top of which rest flat-bottomed rails, connected transversely by tie rods. The cost of this permanent way on the Metropolitan Railway has been £981 4s. per mile—the cost of maintenance is estimated at £60 per mile per annum. The weights of sleeper and rail are respectively 49·14 lb. and 50·9 lb., or a total of 100·04 lb. per yard. Whether the adoption of this system will prove a success time will show; at any rate, it is an experiment the result of which will be looked for with interest by many, particularly in Germany, where the adoption of iron instead of wooden sleepers finds favor with the leading authorities. Scarcely less interesting than the line itself are the stations, which are divided into two stories, the lower one on a level with the ground containing the offices, waiting-rooms, etc., the

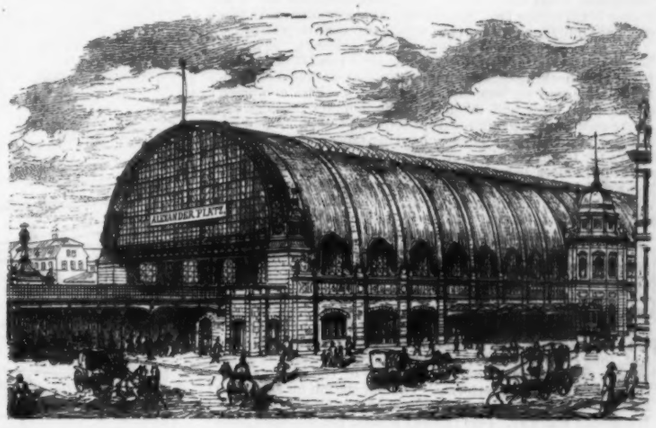
MUSEUM ISLAND BRIDGE.

STOCK EXCHANGE DEPOT.

STREET BRIDGE.



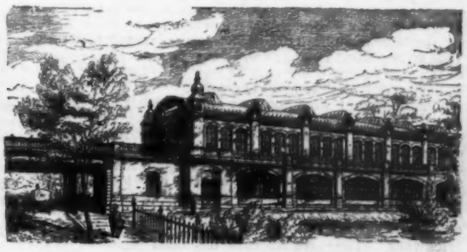
FRIEDRICH STREET STATION.



ALEXANDER PLATZ STATION.

CASTLE BELLEVUE BRIDGE.

VIADUCT.



BELLEVUE STATION.

SPREE VIADUCT AND MICHAEL'S BRIDGE.

LAND WEHRKANAL BRIDGE.

SILESIAN DEPOT.

CHARLOTTENBURG ROADWAY BRIDGE.

SCHIFFBAUERDAMM BRIDGE.

THE METROPOLITAN ELEVATED RAILWAYS OF BERLIN, PRUSSIA.

upper story consisting of the platforms and the lines only. The two systems of traffic described at the commencement of this paper necessitated the adoption of two different types of stations—one for local traffic only, the other for local and through traffic combined. The stations for local traffic only are built on the following type: The two lines for local traffic, which are generally separated 11 feet 6 inches from center to center, leaving 6 feet 9 inches way between the rails, are spread out to about 40 feet for a distance of 500 feet. The platform is built within this space, and communicates by two broad staircases, one for ascending, the other for descending passengers, with the offices below. This platform is inclosed by two walls, and roofed over for a distance of about 330 feet. The two lines for through traffic are only widened out sufficiently to provide room for the supporting wall of the roof. Where two stations of different type fall together, the two outer lines are bent outward to the same width as in the first type, 40 feet; the two center ones running through two platforms, are thus formed, roofed over for a length of 500 feet. The arrangement of the viaduct at the stations is as follows: In the first type "stations for local traffic," the viaduct is continued in a width of three lines right through the station, and the fourth line only branched out. In the second type, the viaduct runs right through only in a width of two lines (the two center lines), and the two outer lines branched out. The spaces between the two, respectively three branches of viaduct, are built over with arches which support the platforms. These arches are pierced by skylights to illuminate the rooms below. The stations for local traffic only consist of a large hall, with booking-office, small waiting-room-offices for station-master and porters, and large w. c.'s. The combined stations for local and through traffic contain, besides the above-mentioned accommodation for local traffic, large waiting-rooms for all four classes, booking-offices, cloak-rooms, offices for the expedition and delivery of luggage, post and telegraph offices, cabstands, and approaches. The station in the Friedrichstrasse contains, besides, large rooms for the convenience of the Imperial Court. It will be seen that the character of a viaduct has been maintained throughout, even in the construction of the stations. The reconstruction of the old Frankfurt, now Schlesische Railway Station, to make it available for the Metropolitan Railway, necessitated some very important alterations. Formerly on a level with the street, the platform and rails had to be raised about 23 feet. The lofty roof permitted this to be done without interfering with its architectural features. An extension on the north side of the station, about 200 feet wide and 656 feet long, was rendered, however, necessary, and this extension is constructed to hold six lines of the Metropolitan Railway with three platforms. The old station on the south side contains, as before, the five lines of the Niederschlesisch-Märkische Railway. This railway station has not been built on viaducts, but on an embankment between retaining walls. Three passenger and four luggage tunnels intersect transversely the station, and above these another tunnel, with three narrow-gauge lines of railway for goods-transport, is placed; fourteen hydraulic lifts raise the goods to the level of the platform. These are worked automatically by a nominal 14 horse-power engine, working two accumulators, arranged in such a manner that as soon as the accumulator weights lift, the engine stops, but when the pressure in the accumulator is reduced the engine starts again automatically. This arrangement is said to work very well. In consequence of the total height being only 23 feet, the tunnel for goods traffic has only a clear height of 9 feet.

This important work, costing about £600,000, was completed in nine months, without interrupting the traffic of the then Frankfurt terminus. The roofs of the stations are built of light iron segmental arches, with a pivoted joint at the crown, and covered with corrugated iron sheeting. They are supported by posts of I section, two of which are built into each pier of the viaduct, "and connected at the springing of the roof by a girder of [section," on which the principals rest. The spaces between the posts are filled in with brickwork. The greatest care has been bestowed on the architectural development of the stations, which are an ornament to the town and a credit to those who designed them. The rolling stock will at first consist of 100 carriages and 60 locomotives. The latter are tank engines, with four wheels coupled, and a load of 12 tons per axle; they are provided with Smith Hardy's vacuum brake and use coke for fuel. The carriages are built on the compartment system, and have only second and third class. To enable carriages of all description to run over the Metropolitan Railway, it was resolved not to depart from the universal type of platform adopted in Germany, which is about 9 inches above the level of the rails. To facilitate, however, entering and leaving the carriages, those of the Metropolitan Railway have the floor placed beneath the axles, thus enabling passengers to enter and leave by means of one footboard. The trains will be in charge of a driver and a stoker and one guard, and the same system adopted on the London Metropolitan Railways for checking passengers put in force. The fares have been fixed very low: namely, 6d. second-class and 4½d. third-class for the whole journey, and 2d. and 1d. respectively for shorter journeys. A reduction of 10 per cent. will besides be granted to purchasers of ten tickets, available at any date. The total expenditure may be roughly divided as follows:

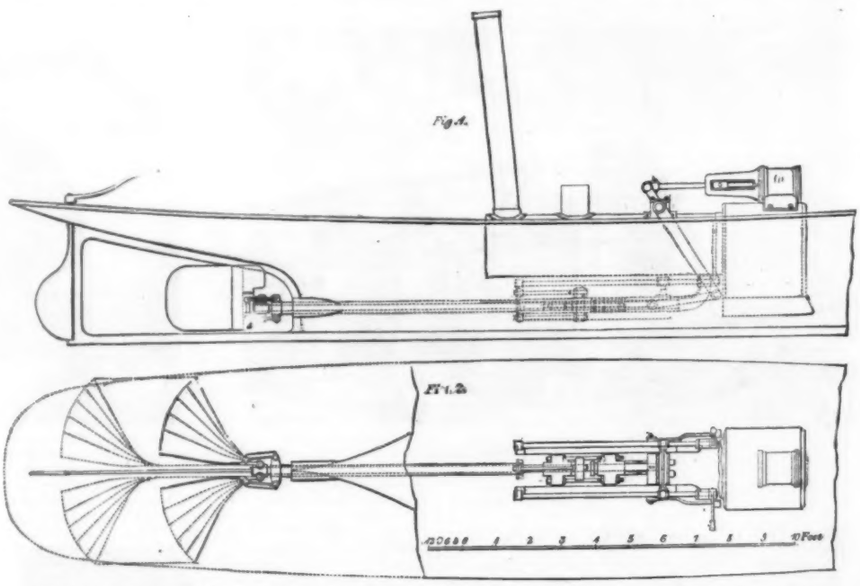
Ground property	£1,150,000
Viaducts	950,000
Earthworks, embankments, etc.	25,000
Eastern terminus	260,000
Western terminus	300,000
Iron structures and permanent way	100,000
Stations and approaches	250,000
Rolling stock	125,000
	£3,160,000

Adding to this incidental expenses and interest on capital since commencement of line, the total expenditure will be about 3¼ millions, or close upon half a million sterling per mile. The return on this expenditure is not estimated at present at more than 1¾ per cent.; the receipts from traffic being estimated at £90,000 (taking the number of passengers at six millions only); from the rental of arches, £10,000, in all, £100,000, from which deducting 50 per cent. for working expenses, leaves £50,000 net return. These figures are based on the present traffic statistics of Berlin; but when we consider the great facilities of communication offered to the inhabitants by this new railway, and that in all cases increased facilities and traffic react on each other; there is no reason to doubt that this traffic will be enormously increased, and eventually a handsome return shown for the money invested. The benefits the line will confer on the town are undoubted, enabling the inhabitants to spread themselves over a larger area, and reducing the number of inhabitants in the city itself, which at present has, on an average, fifty persons to each inhabited house; whereas in Paris the proportion is thirty; in London, ten; and New York, eight. The whole of the works have been designed and carried out under the able superintendence of Geheimer Regierungs-Rath Dircksen, who also built the Ring Railway; to whose courtesy and kindness I am indebted for the foregoing facts and the drawings exhibited.

Our sketches are from the *Illustrirte Zeitung*.

IMPROVED FEATHERING PROPELLER.

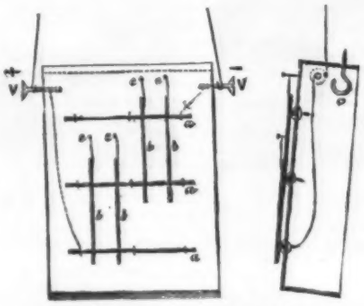
MESSRS. DUNCAN BROTHERS, of 32 Queen Victoria Street, exhibited at the recent naval exhibition, London, a steam launch fitted with Welton's feathering propeller. Of this launch we publish an engraving. Welton's propeller consists, as will be seen, of a pair of flexible blades which—for forward propulsion—are alternately brought together and drawn forward through the water, and then spread and forced backward. For going astern the movements are reversed. The backward and forward motion of the propeller blades is given by a shaft which passes through the stern of the vessel, very much in the position occupied by an ordinary propeller shaft, and is connected to the lower end of a pair of vibrating levers, the upper ends of which are connected to a piston working in a steam cylinder placed on the top of the boiler as shown. There is no rotary motion, the valve of the steam cylinder being worked by an arrangement of tappet gear. This arrangement of propeller is specially intended for use in shallow water.



STEAM LAUNCH WITH WELTON'S FEATHERING PROPELLER.

ERLACH'S IMPROVED BICYCLE.

SOME of the main defects of the modern bicycle with a large driving wheel, and the seat over this driving wheel, are the difficulties experienced in mounting the bicycle, and the danger of falling over whereby the rider is frequently more or less seriously injured. In Erlach's bicycle, shown in the annexed cut, the large rear driving wheel is operated by means of crank treadles and connecting rods, by the rider occupying the seat above the small front steering wheel. The rider can easily mount the bicycle, and if the same is upset or strikes against stones or other obstructions, he can easily place his feet on the ground, and thus save himself from falling over with the bicycle. Beginners will certainly find the above described vehicle much more agreeable and convenient than the bicycles of the usual construction.



ERLACH'S IMPROVED BICYCLE.

This bicycle is manufactured in Korpitz, near Villach, in Austria, by the inventor, Joseph Erlach.

EASY PROCESS OF MAGNETIZATION.—The so-called method of M. Elias, which has been used by M. Jamin and carefully studied by M. Gaugain, is as follows A coil of thick wire is traversed by an intense current: it is composed of 10 to 20 spirals, and is very short in its axial dimension. The plate or rod of steel to be magnetized is passed through it, and a few passes suffice to give saturation.

HOW THE SHOEMAKER SHOULD WORK SOLE LEATHER.

ONE of the prime requisites to the making of a *good shoe* from any kind of sole leather, is that the leather shall all be in proper temper. By a good shoe, we mean one that shall not only appear well, and show a good finish when fresh from the hands of the finisher, but shall also remain bright and fresh, without showing any evidence of warping or cracking on the edges or heels.

Special treatment is required for every variety of leather. No two kinds, and frequently no two sides of the same kind of leather, take water equally in the same time. All leather, however, admits of some general directions in the matter of soaking.

Sole leather should always be soaked in clean water, each kind by itself, no two kinds being ever placed in the same water, either together or one after the other. Always use clean, fresh water. Soak the leather until the water meets in the center, or near it. At this stage of tempering, it is best to err on the side of getting the leather too wet than not having it soaked enough; and testing the question by cutting the edges of the leather afford no reliable information of the condition of the leather in the middle of the strip or side. If the leather is stripped before being soaked, cut some strips double lengths, and when supposed to be wet enough, cut through the middle, and the true condition of the lot in soak will be exactly known.

If wet completely through, take it all out and stack it up to drain and mellow one or two hours. Then spread it around in such a way that it will dry on both sides evenly, but not too quickly. When nearly dry, stack it again to mellow, and the moisture in the middle of the leather will distribute itself evenly all through to the grain one way, and to the flesh the other. When this is accomplished (which can be tested by cutting a strip in two when it is a question of doubt), spread the leather all out again, and as soon as the grain is dry pass it all through the rollers; if rolled too soon, the grain will be blackened or darkened, and often work as though burned, and sometimes as though oiled, showing the most prominent in the thickest parts of the leather. Then stack it for use, and if given to the workmen in fair condition, insist that the leather shall not be wet again until it reaches the trimmer, who should only be allowed to moisten the very edge; for although at the beginning of tempering leather it is best to be sure it is fully wet enough, at the end or in working it up it is much more important that care be taken to have the leather fully dry enough. Shoes made from leather that is too wet always crack on the edges and around the heels. The worst condition, however, in which to work leather is to have one part wet while another part is dry. Rolling, hammering, or the application of friction should not be allowed on wet leather. A proper close attention to these details will insure for the bottom—if care is taken in buffing with a fine edge buffer—a fine rich velvety surface, and the heels and edges will retain all the luster imparted for several months.—*Shoe and Leather Review.*

CONCRETE FLOORING.

IT would be very desirable if manufacturers of cement and concrete were to supply the profession with the results of experiments on the strength of concrete slabs. There are, it is true, a few published statements respecting the strength of concrete, which are sufficient to show the value of the material for floors and bearing surfaces, but they lack the authority that would be given if a few well instituted tests were made and published. It is with regard to tensile strength that the profession would like to be informed more particularly, since the use of concrete for floors, staircases, and landings is increasing.

Some experiments by Mr. Reid, made to determine the tensile value of "rock concrete" pipes showed an average in several series of tests of 443·6 lb. per square inch. The highest strength recorded was 700 lb. per square inch, and the lowest 213 lb. These experiments were made upon briquettes cut out of concrete pipes that had been rejected; and they are sufficient to show what resistance may be expected from concrete beams and slabs of the material. Mr. Hyatt's experiments in the same direction may be mentioned as showing the great strength obtained in embedding iron in the form of ties in concrete.

The results of some experiments by Mr. Kirkaldy to ascertain the resistance to a gradually increased bending stress of concrete beams constructed with a flat bar embedded near the bottom, are very satisfactory. They, at least, proved

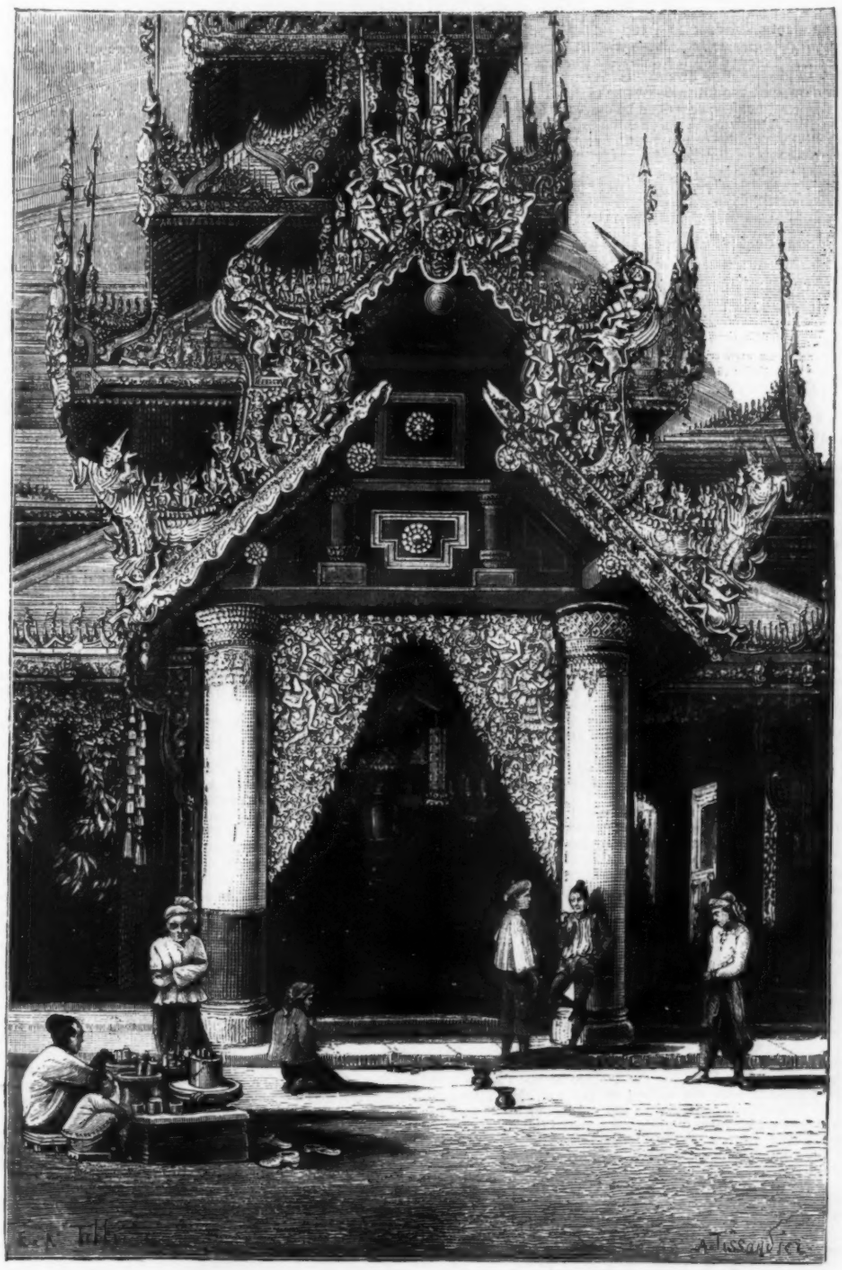
that the compressive resistance of Portland cement concrete was in excess of the demands of the tie-metal introduced, and that by the union of tie-metal with concrete, results equal to riveted or rolled beams are obtainable. But the architect is fully cognizant of the value of combining these two materials, and for floors requiring great strength, such a composite system is excellent. The question, however, is not so clearly answered how a slab of simple concrete of a certain superficial area and thickness will stand a given load. What is the weight it will bear as a dead weight and as a live load without fracture? A few tests upon concrete slabs supported on two edges would not be sufficiently reliable; the experiments ought to be numerous, different kinds of cement and aggregate should be experimented on, and vibration taken into the account. The resistance offered by concrete tubes has been found to be very great, the mean of several cracking tests upon pipes packed in clay, as in the case of a sewer-pipe, being 4,393 lb. A more valuable case to the architect is mentioned in Mr. Reid's treatise on concrete. A slab of "granitic breccia" stone made by Mr. Buckwell many years ago, was cut to the size of 3 ft. by 2 ft. 4 in., its thickness was 3 in. It was supported on two timbers with 3 in. bearings. "Upon it was placed a weight of 3 tons 5 cwt. 3 qrs. 17 lb., which it sustained for about 5 hours, when it broke with a fracture about midway through its length. This was equal to 1,054 lb. per square foot." The composition of this concrete was Auston stone, of large and irregular size, with a heavy dark Portland cement.

Strength is insured by weight and fineness of grinding, and these essentials ought to be required for concrete construction. It may be useful to know that arches of 10 ft. span, with a rise of 10 in. only, and 5 in. thickness of crown, have sustained working loads of 2 cwt. per square foot. As we have said, however, greater research and more experiments are demanded before architects can safely introduce concrete floors without iron, and of any considerable area. They now use concrete in landings and staircases, and for these purposes it has answered all expectations. The intimate admixture of the cement and the aggregate, and the use of materials of the very best kind, are required in all works in which the concrete is made by the contractor. The usual breaking strain specified is from 350 to 450 lb. per inch, and these high standards can be met by mixing and hard burning. We are glad to find a committee has been appointed by the American Society of Civil Engineers, for the purpose of devising a uniform system of tests for cements, the principal difficulty experienced being that the experiments should be conducted with sand of the characteristics found in different localities.—*Building News.*

THE GREAT TEMPLE OF RANGOON.

THE specimen of architecture which is shown in the accompanying engraving is the entrance to the great Temple of Rangoon, British Burmah. This structure, which is partially built of bricks and situated on an eminence overlooking the city, was formerly at the same time a fortress; and, during the second war, when the English laid siege to Rangoon, they had much trouble in taking this stronghold, surrounded as it was by bastions. In the vicinity there are still to be seen the tombs of the English who fell in the attack.

On the exterior of the edifice there are altars which are decorated with gigantic statues of Buddha and other divinities. These temples are extremely rich, decorated as they are by the generosity of the faithful, with diamonds and rubies set in the masonry and buried beneath the foundations. They are looked after by a host of priests who live in sorts of monasteries adjoining the sanctuary. It may be easily seen from the engraving, reproduced from a photograph sent from Burmah by Count Mahé, how great an affinity this architecture has with that of the neighboring countries, Siam and Cambodia.



ENTRANCE TO THE GREAT TEMPLE OF RANGOON. (From a Photograph.)

CAMPHOR BICHLORIDE.—This compound is insoluble in water, to which it imparts, however, its peculiar odor. It is slightly soluble in cold alcohol, but dissolves to any extent at the boiling point. It is very soluble in chloroform, and in carbon bisulphide, and extremely soluble in ether, liquefying even in the vapor of ether. From this solution it does not easily crystallize, the ether being retained energetically. Camphor bichloride is insoluble in acetic acid, in which camphor dissolves. It is soluble in aldehyd, forming a liquid more dense than water. The specific gravity of camphor bichloride is 4·2; its melting point is 96°.

HERR HOF-PHOTOGRAPH VICTOR ANGERER IN VIENNA.

VIENNA has long enjoyed a reputation for brightness and gayety among European capitals. It now bids fair to lead the way by reason of the magnificence of its architecture, the grandeur of its public buildings, and the handsome character of its squares and public gardens. The Ringstrasse, as a thoroughfare, is likely to be unique; the broad belt of fortified wall and glacis, which formerly surrounded the city, has given place to a handsome and airy boulevard, with lofty buildings of white stone, green gardens, and verdant avenues. The fortifications, therefore, if they did not stop the Prussian army twenty years ago, have been useful in peace, if not in war; for, had they not existed, there could have been no open space around the city for the construction of a Ringstrasse, and Vienna would have been the poorer by its finest thoroughfare; while, from a sanitary point of view, it had been bereft of a healthy breathing apparatus. We doubt, indeed, if ever fortifications were put to a better use.

Viennese life has much of the *élan* of Paris life, while being peculiarly its own. The warmer climate permits of more out-door recreation, and consequently cafe and "Vauxhall life" are found in perfection; music is a part of the existence of a Viennese citizen, and waltzing is not an accomplishment, but a custom. The busy streets have a tinge of Eastern life about them—Turks from Constantinople, Greeks from the Levant, and turbaned Armenian Jews are occasionally met. The Graben, Kohlenmarkt, and Kärntner Strasse are always bustling and lively, the Viennese cab-driver contributing thereto his fair quota (for he usually drives a pair), and, with the loosest of reins, maintains his steeds at a hand gallop through the streets, let them be wide or narrow. The handsome Opera Ring (a bit of the Ringstrasse where the Opera is situated) forms a magnificent promenade, and so does the Volksgarten, which abuts the same circular street a little further on. Verily, there is but one Kaiserstadt and only one Ringstrasse.

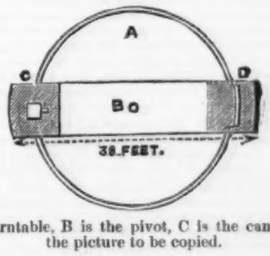
The name of Angerer has long been associated with the Kaiserstadt. It was not Herr Victor Angerer, however, but his brother, who first enjoyed the title of Court photographer. The present principal is one of the most genial of men—suave, polite, and eminently good-natured. He is a keen sportsman, and a great fisherman, besides being an accomplished photographer. A more unpretending, courteous gentleman it has not been our lot to meet.

We visited the Angerer studio ten years ago. Then the glass-room was entirely of blue glass—perhaps the only establishment that has ever been glazed throughout in this manner; but, whatever theory may say as to the benefits to be derived from such illumination, in practice, white light has decidedly the advantage; the blue-glass studio of Angerer exists no longer. The present glass-room of the Court-photographer is very spacious and lofty, and, strange to say, it is the only instance we remember of a studio being "down stairs," for thither we are at once invited to meet our host.

But, though asked down stairs, we do not leave the waiting-room for the moment, and for this reason: A young lady and gentleman have just come from the studio, and are now at the further end of the room in conversation with a clerk who holds a ledger before him in his hands. The gentleman is arrayed in a tie of snowy whiteness, and the young lady, in bridal attire, carries a bouquet. They have been photographed in anticipation of the wedding, and are a little flurried; the lady evidently thinks the man with the book means marrying them out of hand, and perhaps a passing thought that she has been inveigled here for the purpose crosses her mind. In any case, she will have nothing to do with the clerk. The gentleman is equally timid, and objects flatly to give either his name or address, under the impression that he is being taken advantage of. "I have paid, and that's enough," cries the bridegroom. "But, sir, we must have some address to which we can send proofs," urges the book keeper. The customer begins to see there is some force in this argument; but after a moment's thought he relapses into his fit of obstinacy again. "No, you don't want any address; I will call," and away rush the timid lovers.

The studio where Herr Angerer bids us welcome is said to be the largest in Vienna. It measures fifty-four feet in length, and at its highest is twenty-five feet. A gallery runs along the top of the room, which then slopes gradually down to the glazed side-wall, looking into a cheerful garden. Indian straw-matting is hung about the room, forming alcoves here and there, under the gallery; and altogether the apartment has the appearance of a fine conservatory or palm-house. Blue hangings are to be seen on the glass side, while brown hangings for the most part are on the other. For backgrounds, too, Angerer occasionally employs screens of straw or cane, such as are to be found in drawing-rooms, and in this way he produces portraits that seem to be taken at home. One movable screen we saw was very practicable, as it permitted the lighting up of the lower part of the sitter's garments most effectually. It was simply a stand with two movable surfaces, the top being of light blue, and the bottom of white, as shown in our sketch (Fig. 1). Herr Angerer always poses, and indeed is a very hard worker in the studio.

Fig. 1.



A is the turntable, B is the pivot, C is the camera, and D the picture to be copied.

We walk out into the garden. There is here a Swiss chalet or garden-house, with balcony, etc., erected solely for the purpose of taking groups and out-door pictures. It is painted a dark-gray, the best color, Herr Angerer finds, for a photographic background in the open. But what our host desires more particularly to show us is his enlarging apparatus, which is a wonderful structure. Imagine a turntable, as large as those to be seen on our lines of railway;

rails are laid down in a circle, and this big table on wheels then turns on its axis. The diameter of this circular table is no less than 38 feet. At one point, on the circumference of this table, is located the camera, with a recess or alcove built over it, and directly opposite, at the other margin of the table, is another small structure, under which the picture to be copied is placed. Here is a sketch of the whole arrangement (Fig. 2): The camera under its alcove can be

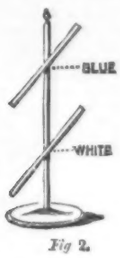


Fig 2.

advanced and retired at will toward the picture. As both the camera and picture are in this way boarded over, no objectionable rays of light can strike either one or the other, while from the fact that the table carrying camera and picture can be turned in any direction, it is possible to choose the very best light for the object. The photographer focuses the picture, and then, while still gazing at it on the focusing glass, gives the word to his assistants to revolve the turn-table; when the lighting is at its best, he cries "Halt!" the table is fixed, and the exposure is made. No rays but direct rays fall upon the picture. Certainly the arrangement is very perfect, and it is carried out on a grand scale.

"I only wish I could print faster," says Herr Angerer, alluding to his large negatives of four and five feet that stand here in their frames in deep shadow. Both silver and carbon printing—the only place in Vienna where we saw carbon printing—are here in operation; but Herr Angerer cannot get satisfactory results, he says, unless the light is very diffused; and this brings us to the subject of enlargements, which Herr Angerer produces in a different way to that in vogue in this country. Moreover, when we detailed our usual method of making a small transparency in carbon to begin with, he replied that he had tried it repeatedly, but that it did not yield him such perfect results as his own plan. This is to make from the small negative a large collodion positive, in the first instance, which is done in a dark room fitted up like a huge camera; from this collodion positive, after careful retouching, is printed in a printing-frame a carbon print, which is developed on a glass-plate. This large carbon impression on glass is of course negative, and rarely requires further touching before being employed to produce the finished print. The elaborate retouching is all on the first collodion positive, and not upon the carbon negative, and Herr Angerer believes that when the retouching has been thus translated, the finished effect is better.

Dark rooms and developing rooms open from the studio, which, as we have said, is "down stairs," from the front of the house, although on a level with the back garden. So that the washing-rooms and laboratories are half-cellars, exquisitely cool and dark. Herr Angerer employs for his washing, fixing, and toning baths, very large, but very shallow wooden tubs, like low washing tubs, which are, indeed, exceedingly practical.—*Photographic News.*

STORAGE OF POWER.*

By PROF. W. E. AYRTON, F.R.S.

THE subject of this lecture has been called by the world at large, and even by the well-informed *Punch*, "Storage of *Fbres*." Why, then, have I ventured to differ from so public an authority in my title? The fact is that it is as impossible to store force as to store time. There is as much difference between force and power as between a mile and the speed of a railway train. Power involves two ideas combined; Force only one. For instance, I have on this table a piece of wood; it presses the table down with a certain amount of force, and the table presses its weight up with an equal and opposite force. But that is not storage of force. The mere resting of this weight on the table stores nothing, and it is beyond the power of the most accomplished engineer to move a machine simply by a direct weight on the table. The very name, dead weight, shows how useless such an arrangement is for the production of work. The weight on the safety valve of a steam engine may control the pressure at which it is working by liberating the excess of steam, but such a weight can, of course, never work an engine. What, then, is the other component idea, in addition to force, that must be present in order to produce work? The answer is, motion. Work is force exercised through space. If I raise this wood, I do a certain amount of work. The operation of raising it is doing work, and the greater the weight raised, and the greater the distance from which it is raised, the greater is the amount of work done. The raised weight is in a different condition from what it was when on the table. When I raise it, it can fall, and in falling do useful work. The raised weight store of power we employ to drive our clocks, to help us to open our windows, to raise our chandeliers, and also for many other useful purposes. The continuous evaporation of the waters from seas and rivers by the heat of the sun also supplies us with a large raised weight store of power, because the water can fall upon the hill sides, and in doing so turn water wheels and turbines. The vast fields of coal underground also give us an enormous store of power. The initial work in these cases is analogous to the winding up of a clock, being performed by the leaves of plants and trees, which under the action of the sunshine, form wood, and this, after lying long ages, turns into coal. But there are other substances beside coal and oxygen which we find separated in nature, and which, therefore, form stores of power. For example, blocks of pure copper, which are found near Lake Superior, are a very valuable store of power. They are too valuable to be used as a fuel, and, in addition, they are only poor heat givers, but still they have in them, of course, a very large amount of power. Zinc is rarely found pure and uncombined in nature, but when separated from the oxygen which it usually contains, the tendency of the zinc and the oxygen to come together forms a very valuable store of power, in fact, almost the sole store of power made use of by telegraph companies in galvanic batteries, etc., to work their telegraph instruments. In all the preceding cases, the store of power is produced by the separation of two bodies wanting to come together; and you may remember that about this time last year, in my lecture upon the production of electricity, I showed that an electrified body could do work if separated from another body charged with an opposite kind of electricity. We may also have a store of power through two bodies being too near together, and wanting to part from one another. For example, in a coiled spring, in a reservoir of compressed gas or air, or in two similar electrified or magnetized bodies. I have got here several examples of stored power, which we shall now utilize one by one.

In a series of experiments the lecturer showed how a falling weight may be utilized to do such work as turning a grindstone, and how a head of water could be made useful in turning a water wheel and so raising the weight; and also how, in a gas engine, the potential energy of the gas could be made to work a saw or turn a lathe. Finally, an illustration was given of the power of electric energy produced by the tendency of zinc and oxygen in a battery to come together. The lecturer continued: We have also another store of electrical power of a different kind, of which I shall have to say a good deal later on. The water in the cistern above the lecture room, which was utilized for turning a wheel, was pumped up for domestic purposes and not primarily as a source of power. Of course, natural stores of water power on the hill tops can be utilized for similar purposes, but artificial sources can be employed by such means as Sir W. Armstrong's water accumulator. If we pump water into a cylinder of a hydraulic ram, we can raise enormous weights, as, for example, in steel works, for moving about masses of steel, or in docks, to open gates. But it would be very inconvenient to have to pump the water every time we wanted to move the piece of steel. To avoid this, water is pumped periodically into the cylinder, which contains a piston very heavily weighted; and in the gradual falling of the weight, the piston forces out the water, and supplies the necessary amount of work in any part of the factory as required. Such a hydraulic ram is only a form of the raised-water store of power, and of the same nature is the weight wound up in the clock. I want to consider how far it is possible to use these various stores of power for the purposes of driving, say a tram car, on an ordinary London road. An ordinary tram car weighs about two and a half tons, or, when full, about four and a half tons. To drive such a car as this requires an expenditure of about one and a half horse power, to produce which for one hour means about 2,800,000 foot pounds of work. Supposing, then, this amount of work were to be produced by a weight raised up on the car and falling during the journey, by which to move it, what would be the weight required? If the distance to which it was raised were ten feet, it would require a weight of about one hundred tons. Hence Armstrong's accumulator, so valuable in the manufactory, would be absolutely useless for such a purpose, because the weight raised at the commencement of the journey, and the gradual falling of which was to drive the car, would be the utterly unmanageable one of one hundred tons. Springs coiled up at the commencement of the journey might be tried, the uncoiling of which would drive the car, but this would be hopelessly cumbersome and impracticable. Steam engines are occasionally employed, as you know, and from the point of view of economy are superior to horse power; but the disadvantage of the noise, and the smoke, and the terror of the horses in other vehicles, is against them. The detached steam engine, too, weighs about as much as a full car, so that the horse power employed in pulling the two would be simply moved in moving the engine and boiler. The detached engine, too, loses heat from the boiler very rapidly, and there is also a considerable waste of oil and tallow, etc.; and when cleaning it causes an expenditure which is not so much felt with stationary engines. Consequently the fact that steam engines are more economical than horse power only shows how hopelessly uneconomical this latter method of traction, the remnant of the old coaching days, really is. The gas engine, worked with ordinary coal gas, probably compressed in cylinders on the car might be employed, and it would be a great saving in weight in the absence of the boiler; but although it is possible to use this, it is not at all economical, though instead of ordinary illuminating gas, a cheap heat-giving gas, like that of Dowson, could be substituted. Still, the weight of the gas engine is so very much greater than the steam engine per horse power employed, that it is almost impossible to use gas engines for any such mode of propulsion.

Compressed air engines have been employed comparatively recently, with a certain amount of success, by Colonel Beaumont, on the North London Tramway; but they have some disadvantages which attach themselves to detached steam engines, that is to say, the weight of the engine is so large compared with the weight of the car, that although Colonel Beaumont succeeded in putting in one cubic foot of air compressed to 1,000 pounds pressure to the square inch, he could only drive a car three tons in weight half a mile, and the compressed air engines weigh about seven tons, whereas the car only weighs about five. That is to say, seven-twelfths of the whole power is employed in merely pulling the compressed air engine. To obtain mechanical motion we require a store of power, and some method of converting the energy stored into mechanical work. Now, experiments show us that the weight of an electromotor is very much less than the weight of a steam engine and boiler for the same horse power developed. For example, take this little machine which I hold in my hand. It is quite light; you can move it about easily; it is only attached by two wires, so that I can do what I like with it; yet see with what facility I can drill holes in this piece of wood. Or, take again this electric hoist. It is comparatively light and easily fixed, and yet by means of it we can raise tolerably large weights. It is worked by an accumulator lying on the floor, that is using only a small fraction of its power. This hoist raises weights easily, and it is a great advantage that you can raise the weights while the hoist is moved; while the only connections necessary to transmit the power are simply these quite flexible and light wires. In the case of an ordinary traveling crane, worked by a steam engine, whenever we want to move, we have to move both engine and boiler, because they are all one. Now, experiment shows that you can get in this way electrical power at the rate of about one horse power per fifty pounds dead weight only in the electro-motor. Hence the enormous advantage possessed by the electromotor for traveling machinery.

Let us turn our attention to our storage of power converted into mechanical work by the agency of electricity. I said that telegraph engineers mainly employed the potential energy of separated zinc and oxygen, but such a store is by no means an economical source of power, because the *maximum* amount of work obtained out of burning a certain quantity of zinc is only about one two-hundredths of the maximum of work to be got by burning an amount of coal of the same pecuniary value. The energy of coal is what we have to employ if we drive steam engines or gas engines. It is all the store we draw upon when we use electro-motors, that is, coal will be put into the furnace to produce mechanical motion. The motion of the engine will work the magneto machine or the dynamo machine, producing an electric current, which may be transmitted to any distance that you find requisite. [The lecturer here showed how power from a gas engine could be transmitted to the distant wall of the building in order to turn a wheel.] He continued: Small variations in the speed of the engine or the dynamo machine can be avoided by having a heavily-rimmed fly wheel on the engine or on the dynamo machine; and in fact dynamo machines driven with gas engines are fitted usually with such a heavily-rimmed fly wheel, turning at the rate of about a mile a minute or so, in order to keep up a uniform speed. We may use such a machine for any kind of power, or to produce an electric light. Of course, if a strap breaks, or the steam is allowed to go down, it is impossible to keep it up. To avoid such mishaps, what we want is some sort of electric accumulator—some sort of reservoir that will suck in the electricity when the engine is working best, and give it out when it is tired. Again, apart from accidental fluctuations of the engine, or total breaking down of its apparatus, there is another enormous importance for electric accumulators. The uses of electricity in this country at present are very much in the same state that Robinson Crusoe was in reference to his clothes. Every man has to manufacture his own electricity, that is, if he wants any; but were there companies actually supplying it as they supply water or gas, then they could lay on the wire, and we could turn on our electric light with as little hesitation as we turn on the tap of the water pipe. The greater part of the gas burned in London is burned, probably, between 6 and 11 P.M., that is, during five hours out of the twenty-four; but the gas works are always working, so as to keep up the store in the gasometers. If, in the absence of stores for gas, it were necessary to make all the gas that is required between the hours of 6 and 11, then the gas works would have to be very much larger and more costly, the capital sunk in them would have to be very much greater, and the price of gas, therefore, would be very much higher. And so it must be with electric lighting. But if only we can arrange so that the electric power can be accumulated, so as to be ready for the time when we actually require it—if it had to be supplied at the same time that it is being burned, the dynamo machines must be larger, the cost very much greater, and therefore the price of electric lighting proportionately higher—that is, if the electric energy could be manufactured during the day and stored till required at night. The experience of the last few years has shown that the lighting of large buildings by electricity is even now more economical than by gas. What will it be when we can manufacture our electric energy—when we can store it and keep it by till we want it? Now the earliest form of electric accumulator is simply a voltameter worked backward. If two plates of platinum be dipped into dilute sulphuric acid, and there is a current sent from one of the plates to the other, as they are placed upright and parallel to each other at a moderate distance, the result is that hydrogen is put on the one plate and oxygen on the other. Previous to your sending a current through the voltameter, it had no power of acting as a battery, but after sending a current a difference is produced in the two platinum plates; it coats one with oxygen and the other with hydrogen.

We have here a rough galvanometer to connect with an ordinary voltameter. I attach it to the voltameter, and show that the mere passage of the electric current from the liquid has endowed these plates with the power of acting as a battery. Now, the two platinum plates cannot store electric energy, because the operation of the current sent through the liquid produces oxygen and hydrogen, which go off in the air, and only very little stays on the plates. Grove found that by coating the platinum plates with what is called platinum black, the storage of electric force could be very much increased. We want to get a good store of electricity for a galvanic cell. Let there be sent a strong current through a short wire. It is absolutely necessary that the resistance of the cell should be very small, that is, the plates must be very near together. One of the reasons why the grooved cell will send such a much stronger current through the short wire than the Daniell cell, arises from the fact that the plates in the one are so very much nearer than the plates in the other. If you place them very near together you must have a porous partition to keep them apart, because if you do not the two liquids will mix. For example, go back to the voltameter: if you put your two plates so close together that the resistance of the voltameter when used as a secondary battery is to give a current which by itself is very small, the oxygen given off at the one plate and the hydrogen at the other will mix together, and the liquid will be practically the same between the two plates, for it will become saturated pretty nearly with the same amount of oxygen and hydrogen, and there will be little reason why the current should pass one way more than the other. We must, then, if we put the plates near together, have a porous partition. We can get rid of this partition if we can arrange our secondary battery so that when you send a current through the battery the same substance is put on the one plate on both sides, which has no tendency to wander or go to the other. It is clear that since the liquid is in the cell, the substance must be solid; and, secondly, it must not be soluble in the liquid. We must then arrange matters so that the sending of the current through the battery for the purpose of charging it shall be some form of solid which is not soluble in the liquid employed. The oxides are such substances, and for that reason lead plates were mostly used in secondary batteries, because the sending of the current through the liquid from one plate to another produces an oxide of lead. In order to have a large storage power the plates must be very large, in addition to being very near together; and to avoid their being hopelessly cumbersome, the plates ought to be made in a spongy condition, because if you have spongy lead on each side, the surface may be very large, and the practical area may not be so enormous. We want, then, two plates near together, and formed of some spongy material.

PLANTÉ'S STORAGE BATTERY.

Now, Planté, who has worked most assiduously on this subject for years, made a spongy lead plate by a very simple process. He took two ordinary lead plates, put them in a liquid and passed a current through one to the other. The effect of doing that is to deposit oxide of lead on one plate and to put free hydrogen on to the other. This went on for a certain time, and then he discharged the battery, which

* A lecture delivered at the London Institution, on Thursday, March 2, 1882.

was then very weak indeed. He now reversed the process. He sent the charging current to put the peroxide on the other plate, and again he discharged it. That kept on for longer and longer time, and giving the plates longer and longer intervals of rest, and by this process after some months he was able to get a cell which had a fair amount of storing power. The great and main disadvantage was the enormous time which it took to make a cell; and, secondly, the storing power, though respectable, was not anything very great.

In the year 1880, Faure thought of the idea of taking lead plates and covering them with tolerably thick layers of ordinary red lead, and then put them in little flannel jackets. He put them near together in boxes, of which I have many specimens, and every alternate plate he connected together, so that there was a large surface of plates very near to each other. The peculiarity of this red lead is that by sending a current through it, it is very easily turned into spongy lead; the charging operation is performed in the same way that, with slight modifications, Planté did it. First in one direction, for a certain time, it changes the red lead into peroxide of lead, and on the other side into a very slight oxide of lead. But this changes the process, and the peroxide is turned into a very slight oxide, and that very slight oxide into peroxide. But the great difference is that in the one case you are dealing with months, and in the other you are dealing with days, or possibly hours, in forming the cell. The enormous amount of time necessary to make the Planté cells prevented them becoming of any commercial value. I should mention that when the cell is formed, and you want to charge it, what you do is this: you send a current through the cells in the same direction as the last current sent, and this has the effect of reducing the suboxide on the one side to pure lead, and make the peroxide on the other slightly more oxidized. Discharging the cell is simply reversing what is done in charging, that is, a small amount of oxygen travels back; therefore the simple act of charging consists simply in the traveling backward and forward of a small amount of oxygen.

Now, does such a cell store electricity? Certainly not. Because when you charge one of these cells, just as much electricity goes out at one end as goes in at the other; and conversely when you discharge it. What do they do then? They do not store electricity, but electric energy, which is quite a different thing. Take the case, for instance, of a stream of water turning a water wheel, which is employed in raising up corn into a granary. That is the storage of corn, but you would not call that the storage of water. Though electricity passes through the cells, and although when you discharge it the electricity passes out, the cell does not store electricity, but electric energy; in fact, storage of electricity is just as much a misnomer as storage of force.

The next point to consider is, first, what is the storing capacity of one of these cells? Secondly, what is its efficiency? that is, how much power can you get out of one compared with what you put into it? Thirdly, what is its durability? Luckily, I am able on this subject to give you something more than mere hearsay, because Professor Perry and myself have been engaged in some experiments on this question. Take one of many examples as to the storing capacity of a cell?

The discharge of a certain cell, which contained eighty-one pounds of lead and red lead, lasted for eighteen hours, six hours on three successive days, and the total amount of work we got out of it was 1,440,000 foot pounds; that is, about one horse power exerted for three-quarters of an hour, or about 18,000 foot pounds per pound of lead or red lead.

In connection with this storage, a very curious phenomenon, which has not received the attention it deserves, came under our notice, and that is the peculiar recuperative power that the cells possess. The omission to observe this is very likely to lead observers to totally wrong results as to their efficiency. You take a cell, charge it, and measure the work put in. Discharge it rather rapidly, till you find no current at all. You may think that you got off not a very large percentage of the total work due from the cell, and you put it by as a bad one. But let it sleep a little; wait, and it will become marvelously invigorated; in fact, it will become quite equal to a new charge. Try it again; it will begin to give off power probably more rapidly than when you began. A certain cell that we hastily discharged until, apparently, it was entirely discharged, gave off three times as much work when we tried it again as at the first discharge; and this particular cell, upon one occasion, when we had discharged it down to two or three ampères, when we tried it again, the discharge was found to be equal to fifty ampères, which is far stronger than is used in any system of electric lighting. On the first day on which we discharged it, the cell had its electricity discharged very rapidly, and the consequence was that the energy was given off perfectly regularly. The next day we took out the energy more quickly, the third day more quickly still, so that in the first three hours on the third day far more energy was given off than in any hour during the first or the second. We managed that by reducing the external resistance; in fact, by doing so, you can discharge practically as fast as you like. You can make it two or three ampères, or two hundred if you wish it.

Next, as to the efficiency—that is, the relation of the work put into the cell to the work given out. And here again the experimenter must be very cautious. When you send a current through anything you necessarily heat it. If you charge one of these cells very rapidly you will heat it, and there is a certain amount of power wasted in heating the cell. If you discharge it very rapidly you will heat it also, and the amount of power it can give externally is partially spent also in heating the cell. It is quite possible to find out by experiment how much power you are putting into the cell, which is usefully employed in producing chemical decomposition, and how much is thrown away in heating the cell. In discharging, also, you can find out how much of the total power is wasted by a hurried discharge. Allowing for this, we found that if the charge is about 1,000,000 foot pounds, and the discharge has a mean value of about seventeen to twenty ampères, the loss of power in charging and discharging need not exceed more than about eighteen per cent.; that is to say, you can get about eighty-two per cent. of the power you put in, which is an enormously high efficiency. I may mention that when we commenced the investigation we were rather skeptical about the results we had seen published. The thing appeared to be too good, and it was only after our own experiments that we found that what we had read was not an exaggeration. It is quite possible that the loss will not exceed about eighteen per cent. if the charging and discharging be not too hurried, and under a somewhat slow discharge the total loss was only about ten per cent., or ninety per cent. of what was put in came out again.

As regards durability, experiments over two months did not show us any evidence of deterioration, so for that time certainly the cells did not spoil, and therefore they probably did not spoil for a much longer time, as there were no signs of deterioration then. I have said that a cell containing eighty-one pounds of lead gave off 1,440,000 foot pounds of work. Consider what that means. That amount of work means sufficient to draw a car containing forty-six passengers about two miles. If you ask me whether they use one cell in a tram car, as it is now practically driven, the answer is, they use more. The reason is that the electro motor is not suited specially to the accumulators, nor is the gearing suited for them. The cells, as at present made, will not give off their energy as rapidly as is necessary to completely discharge one of the cells in a short time, and the consequence is that more cells have to be used. But, on the other hand, a ton of such cells would be necessary to drive a tram car for fifty miles. Spacious as this lecture theater is, it is fortunately not large enough to bring a tram car in, and so we have to content ourselves with the next best thing. To prove that the cell really does contain large quantities of power, we will do some sawing by means of the energy in the cells which I have here before me. We are going to saw by coal burned yesterday on the other side of London. Electricity was produced, put into the cells, and brought to this place yesterday, and we are now going to get it out by means of the electro-motor. [The experiment of sawing was here successfully performed.] We can also obtain electric light through our store of energy. But just as ordinary electro-motors are not made specially to work with these cells, and although one of these cells contains enough power to produce 1,500 candle power for thirty minutes, the ordinary lamps will not give that. In fact, an ordinary lamp would give you no light at all with this cell, because the lamp is not made to discharge it with sufficient rapidity. Just like a man having a good deal of money at the banker's, but he cannot get it out quickly enough, and so he may even be bankrupted. Mr. Edison has been turning his attention to this question, and here is his handiwork, which only arrived last night from America. He has lamps specially made to work with only one or two of the cells of a Faure's accumulator. [The experiment was here made of lighting Edison's lamps. It was brilliantly successful, and the lecture theater was beautifully illuminated, the audience cheering its success most enthusiastically.] One of these lamps, as you see, can be moved about with the greatest facility. We can apply different power to them—two, three, four, up to twelve or a higher number of candles. The ordinary lamps require electromotive force. Maxim's required a great number of cells.

You may be surprised when I talk about measuring the power of the lamp in foot-pounds. How do we get it? Well, it is very easy to understand. Supposing you have a stream of water turning a wheel, the power depends upon two things: first, how much water is flowing; secondly, the height from which it is falling. It depends, in other words, on the flow and the head. Exactly in the same way the power put into this motor depends upon two things, on what we call the potential or electromotive force between the two ends of the wire, and on the quantity of electricity passed through it. I am going to make one or two very short experiments to measure these two things—what will be the equivalent in water to the quantity of water falling down, and the height from which it is falling? We have, so to speak, two streams here, and we want to know the quantity that is flowing, and the difference of pressure between the terminals of the machine. At present the machine is at rest, intentionally; and on our scale we find 15 for quantity and 11 for the potential. The quantity of electricity passing according to a special unit is 15; the difference of pressure is 11; the work now, then, is being all spent on heating the wires. We now let the machine work slowly, and we find that the two readings are reduced respectively to 10 and 16. Now the work done depends on the product of the two. Now set the machine to work very rapidly. The current is now reduced to four and the electromotive force becomes 23. Now what does that tell us? It tells us something of enormous importance. The waste of power depends on the square of the current; whereas the work depends on the product of the electromotive force and the current. The waste of power after heating is proportionate to the waste of power from electric friction. Here, then, we have the three cases of 15^2, 10^2, and 4^2. The total power put in the first case is 10×16, or 160; and the total power in the latter case is 4×23, or 92. In the case when the motor was running slowly the waste of power in heating bore to the waste of power when it was running quickly the ratio of 10^2 to 4^2; *i. e.*, 100 to 16, or about eight times as much work was produced when it was running slowly as when it was running quickly. What does that tell us? If we want to transmit power economically we must deal with small currents on the one side, and on the other with very large electromotive force. We must have very small currents in our wires and very large electromotive force, because the waste of power is proportional to the square of the current flowing, whereas the energy put in is proportional to the product of the two. We can make the produce of the two as large as we like, and the current as small as we like; in fact, if we have a generator producing electricity, and want to send that electricity to some distant place as economically as possible, the current through the wire should be extremely small and the electromotive force must be very great.

Sir William Thomson has calculated that in order to transmit the power of Niagara economically to, say New York or Philadelphia—that is 21,000 horse-power; if you want to reduce the loss of power to only 20 per cent., that is to say, get 80 per cent. out of the power with which you started, then you must have an electromotive force of about 80,000 volts. You can fancy asking Mary Jane to dust a wire which was transmitting 21,000 horse-power: it would be like telling her to keep a flash of lightning tidy.

Last year, at the Society of Arts, Professor Perry pointed out how much would be gained if instead of taking coal from the coal mines you took your engine to the coal and transferred the power by electricity; that is to say, why not place your steam-engine at the top of the coal pit, or even at the bottom, or why not in the seam itself? You can transmit power by two flexible wires just as easily down a mine as down a street; we shall probably have engines driven by coal at the mine some day, as pointed out by Professor Perry last year, and to transmit that power economically will require very high electromotive force in a small current, but with a great difference of potentials between the wires. When you use this power commercially, the Faure battery will solve that question, and probably, although Professor Thomson pointed out that it had not yet attracted much attention, that is the most important of all the uses of secondary batteries. We have got a wire at an enormous difference of potential, and we want that wire to give out at its other end a little of its power for various purposes. How can we possibly do it? Arrange secondary batteries in series, as arranged on this floor, and let a current charge this battery of secondary cells. When you have charged them, simply take, say, 50 of them, and connect the two extremes with two wires: thus you will have a great difference of potential between the two points. When you take these cells away the current perhaps will be only a matter of 100 volts, which is quite a manageable electric force. The secret is to send a weak current with a great difference of potential through an enormous series of secondary batteries at the place where you want to convert the electricity into mechanical work. And then in succession attach the batteries in series of 20 or 30, or 40 or 50, and you will have no difficulty in attaching the two ends, because there is comparatively a small difference of electromotive force, though there is a considerable difference in each of the cells taken individually. It enables us, in other words, does that Faure battery, to reduce this enormous force into commercial value.

So far we have been dealing with things that can be improved by the use of secondary batteries. I now come to the last use which I shall consider to-night, and it is the use of the secondary battery in performing a result which can only be performed by such a battery—the lighting up of a train in motion. If you require that the motion of the train shall light it up, you must have a store of electric power, because if you use a dynamo machine, when the train stops the dynamo machine necessarily stops too. That is what happens if you have dynamo attached to the axle of the wheel, and by that means producing the electric light. But if you use secondary batteries, and if you come to a station, then the electric power produced by the dynamo is stored up, and can be given out so as to avoid leaving the train in darkness. In fact, the Faure battery could act as a sort of fly wheel, taking in the power when the dynamo is working and giving it out when it is not. This is practically being done on the Brighton Railway; and to show you that we can really produce electric light by storage, I have in this theater arranged fifty lights, which would correspond with four lights per carriage to twelve carriages. We will now light them up, and you will see by that how easily it is done and how completely it will answer the end in view. The former uses of the secondary battery are uses which are only important now in a secondary degree; the uses for which we now employ it render electric light in trains perfectly possible and practicable, which was, under old conditions, quite impossible.

MAGIC MIRRORS OF SILVERED GLASS.

A YEAR or more ago, the scientific world was much interested in the very curious effects obtained with the *magic mirrors of Japan*, and several successful efforts were made in Europe to imitate them, the material employed being, as in the imported article, metal.

MAGIC MIRROR.

Recently, Mr. Leon Laurent, an optician of Paris, has greatly improved on these curious apparatus by constructing them of glass—a material which is found in some respects much better adapted for the purpose than metal.

Mr. Laurent has succeeded in constructing two series of the apparatus for lecture and experimental purposes: (1) *Compressed* and *curved* mirrors; and (2) mirrors of various thicknesses and forms (plane, concave, and convex), *heated* in a peculiar manner. For the first of these he uses commercial glass of about one millimeter in thickness, upon which he engraves designs of uniform depth. Glass thus engraved is more flexible than when the designs are in relief. After engraving, the glass is silvered, and the silver is polished. The mirror thus formed is mounted on a standard with the necessary accessories for manipulating it. (Fig. 1.) The following is a brief description of the arrangement, as shown in the figure:

M is a plane mirror silvered on the outer surface. The design is engraved on the back, and is consequently invisible in the ordinary state. The mirror rests against the hollow frame or drum, T, which is movable on the pivots, RS. A is a binding ring lined with cloth for fixing the mirror in place. There are three of these mirrors, one being concave, one convex, and one plane. These may be changed, one for the other, at will, as may be also the rings, A. P is a rubber bulb with which the air contained in the frame may be exhausted or compressed. At R is a cock which permits the exhaustion or compression to be maintained for some time. B is a special cap, having two apertures, O and N, and which is substituted in the lantern for the ordinary tube that holds the lenses. The apertures N and O, limit the size of the luminous point and restrict the divergent fascicle. Finally, in front of the cap, B, and the aperture, N, are seen the two carbons, between which is produced the electric light designed to illuminate the mirror.

The apparatus thus arranged is manipulated as follows:

The cap, B, is placed in front of the light support, and at about one meter away from it, and the magic mirror is placed at about two meters from the cap. The screen is set up near the light, thus making it about three meters distant from the mirror. Thus arranged, if the mirror be left at rest it gives on the screen only a white light, without any figure or design. But if the bulb be compressed with the hand so as to compress the air in the hollow frame, the glass, M, becomes convex, and there is thrown on the screen a *black* and magnified image of the invisible design engraved on the back of the mirror. On removal of the pressure, the mirror assumes its former shape, the image becomes white, and the design disappears. It should be remarked that it is not absolutely necessary to use the electric light; for the oxyhydrogen light, or even a good kerosene lamp (and, under some circumstances, sunshine) will answer just as well. In all cases, these experiments are very curious, and it is, indeed, truly *magical* to see these mirrors, on which no design can be perceived, reproduce on the screen, through the simple compression or exhaustion of the air, the most varied figures, such as flowers, animals, arabesques, etc.

In the second kind of apparatus, Mr. Laurent has obtained another property of mirrors through the dilatability of glass by heat. In this form of the mirror he substitutes ordinary silvered glass of commerce of about four millimeters thickness for the engraved mirror, M (Fig. 1). The implements for producing the figures consist of metal disks, on which are formed the designs in relief, like the one shown at C (Fig. 1). One of these is heated to a point where it can be just touched without burning the hand, and then applied to the silvered part of the mirror, when the designs will immediately exhibit themselves *in white* on the screen. As the mirror becomes heated by the application, a cold disk is substituted for the hot one, with the result of giving on the screen a design *in black*. By placing two of the figured disks, one of them cold and the other hot, on the mirror, two images may be obtained—one white, and the other black. The thickness of the glass makes no difference in these experiments; nor does the varnish which protects the silvering have any effect on the results. As the metallic disks, with figures in relief, are pretty expensive, there may be substituted for them designs made as follows:

Take an ordinary visiting card and trace upon it any design whatever; then, with a pin, prick through all the lines of the drawing so as to have the design in relief on the other side. Or take a piece of tinned paper, such as that usually used for covering chocolate, and make the drawing on the plain surface, bearing down pretty hard so as to have the design in relief on the metallic side. By applying a design made in this manner to the silvered side of the mirror, and holding lightly against it a plane heated disk (Fig. 1, D), the design will be reproduced in white on the screen.

An explanation of the theory of these interesting apparatus may be given in a few words, as follows:

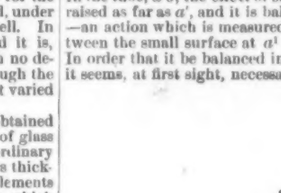
If we suppose a mirror to be absolutely plane—that is, without the least elevation or depression on its surface, it will reflect light uniformly, and the image that it gives on a screen will be perfectly white. But if there be a slight irregularity in the surface, the rays that such irregular part receives will no longer be sent normally to the surface of the mirror, and hence there will be a diminution of the image on the screen—that is to say, the production of a shadow. If this irregularity follow the lines of an object—of a flower or of a letter, for example—the shadow will conform thereto, and there will appear on the screen an image of the object; and, according as the designs are depressed or in relief, the image will be black on a white ground, or white on a black ground. Now, the description that we have given of the apparatus as modified by Mr. Laurent, shows how the compression or exhaustion of the air, as well as the application of heat, has for result the production on the surface of the mirror of very slight elevations and depressions corresponding to the elevated or depressed designs, invisible on the mirror itself, but rendered visible on the screen because of the power of the luminous source employed to reflect the image from the mirror.

AN ILLUSORY PHENOMENON.*

ALLOW me to describe an experiment which, at first sight, seems as if it must realize perpetual motion. Into a cylindrical capsule of sufficient dimensions let us pour distilled water till it reaches a height of about one centimeter; let us insert into this one of the extremities of a glass tube of small internal diameter, say 1·5 mm., and from 8 to 9 centimeters in length; and let us support the tube in a properly inclined position, so that the water which ascends therein through capillary attraction shall occupy a great portion of its length. Now let us procure a second tube, having, we will suppose, an internal diameter of 3 millimeters, and the length of a few millimeters, and let us draw its extremity out taperingly, and bend it over so that it forms a somewhat sharp angle with the wide portion. Let us introduce into the upper orifice of the inclined tube the tapering end of the vertical one until it reaches the water contained in the former; and let us give the wide portion a vertically descending position, either by modifying the angle above mentioned, or the inclination of the other tube. Let us suppose that the orifice of the vertical portion does not reach the liquid in the capsule; and, finally, let us imagine the tapering portion, as well as the vertical, filled with water. To make the matter clearer a sectional elevation of the apparatus is given in the cut annexed; where $a\,b$ is the inclined tube, and $c\,d$ the vertical one. Owing to the small extent of space included between the tapering portion and the interior of the tube, $a\,b$, capillarity will hold the water near the orifice, a, of the latter; but, let us suppose that it stops at a^1. As the lower extremity of the tube, $c\,d$, does not reach the liquid in the capsule, this tube, with its tapering portion, will form a siphon whose shorter leg dips into a liquid in equilibrium and whose longer one extends downward several centimeters lower than the surface of the said liquid. Does it not seem from this that the water must flow continuously through this siphon in order to go and join that in the capsule? Now, if that should happen it would evidently form a perpetual motion.

But the impossibility of a perpetual motion being demonstrated, I have asked myself what would in reality occur under such conditions as the above. I have consequently asked Mr. Van der Mensbrugghe to try the experiment; and this he has done under my directions,† employing for the purpose tubes of the dimensions given above. The following is what we have ascertained: the water, instead of flowing out through the tube, $c\,d$, rises, on the contrary, into the latter and continues to be sucked up until its free surface reaches a certain point of the tapering portion, after which all comes to a stand-still. Only it is necessary, in order that suction shall occur, that the orifice of the tube, $c\,d$, be several millimeters above the liquid of the capsule. If it is lower, the tube, $c\,d$, will remain full and the water will be suspended therein.

A little reflection soon led me to understand the cause of these phenomena that are apparently so singular. The small surface which terminates, at a^1, the liquid between the two tubes is concave in a transverse direction, and therefore exerts, by virtue of such curvature, a suction on the whole mass of liquid to which it belongs, that is to say, upon the liquid in the tube, $a\,b$, and upon that in the tube, $c\,d$—the latter liquid communicating with the other through the tapering tube. In the tube, $a\,b$, the effect of such suction is to keep the water raised as far as a', and it is balanced by the action of gravity—an action which is measured by the difference of level between the small surface at a^1 and the water in the capsule. In order that it be balanced in the same way in the tube, $c\,d$, it seems, at first sight, necessary that the difference of level



between the small surface of a' and the orifice of the tube, $c\,d$, should be equal to the preceding, and which would require that such orifice should reach the water in the capsule. And yet we have seen that an equilibrium subsists even when the orifice under consideration is several millimeters higher. But that is because the water, as a consequence of a tendency to absorption, presents a slightly concave surface, and that the latter exerts, on its part, a slight suction upward, which, combined with the incomplete action of gravity, compensates for the suction emanating from a', with a greater distance from the orifice to the water in the capsule, the suction at a' is in excess, the liquid is drawn upward in the tube $c\,d$, and this motion stops when the free surface of the liquid has reached a point in the tapering tube where the suction due to its concave curvature balances that of a'. Such is a simple explanation of the effects observed, and this little experiment affords a curious example of the suction exerted by the concave surfaces of liquids. It shows us, besides, an equally curious exception to the working of siphons.

A hint to the seekers after perpetual motion!

* By J. Plateau, Member of the Royal Academy of Belgium.

† The illustrious author is, himself, blind.—ED.

SALICYLIC ACID IN THE TREATMENT OF YELLOW FEVER, CHOLERA, ETC.

WE have received the following interesting paper from Dr. T. Brown Henderson, F.F.P. and S.G., of Glasgow:

The admirable researches of M. Pasteur, the French chemist, regarding fermentation, led Professor Lister to his theory of destroying and excluding germs from wounds, etc., which has done so much for the surgery of the present day.

Dr. Déclat, of Paris, claims to have received light from the same source; and a year after M. Pasteur's discovery, Dr. Déclat began the treatment of medical diseases by destroying the germs that produced disease; he named them *ferments*, invisible organisms, which give rise to certain diseases. Dr. Déclat began and continues his system as a proprietary one, thus endeavoring to restrict the use of the medicines to those prepared by himself. Science and benevolence, in Britain at least, cannot be confined to selfish purposes. The writer of this little paper sends it forth with a view to spreading abroad the knowledge of facts useful to humanity, and suggestive, he hopes, to other minds in discovering the causes of disease.

In the *Comptes Rendus* of the Academy of Science, Paris, for July, 1881, we find the following: "Mons. de Lacaille, Rio de Janciro, writes: The 'Medicine de Ferments' gives me great satisfaction. During the months of April and May I attended twelve cases of yellow fever. One of them was most remarkable. A young lady twenty-three years of age had been ill for five days. She had reached the stage of black vomit, hemorrhages, suppression of urine, etc.; the attendants were in a state of great alarm. I had recourse to energetic medication, injections under the skin—solution of phenique (*i. e.*, carbolic) acid, solution of phenate (*i. e.*, carbolate) of ammonia—at regular intervals, and injections by the bowels of solution of sulpho-phenate (carbolate) of ammonia. By the third day of this treatment she was safe. During the thirty years that I have treated yellow fever it is the first time that I am assured of having saved one from death at this stage. In a dozen other cases there was equal success. These other cases have been so quickly out of the disease that I have asked myself were they really cases of yellow fever? Called in at the period of incubation, or before development, the cure was easy."

Cholera has long been looked on as a mysterious disease. It has been successfully treated by salicylic acid. In the *Englishman* and *Times* of India, September 30, 1877, Surgeon Major Boustead, of the Bombay army, writes: "Most favorable results have been obtained in the treatment of cholera by salicylic acid. It has been tried in Cashmere, and the natives prefer it to every other mode of treatment offered. It occasionally requires the aid of a dose of opium, if purging or vomiting are very excessive, and that the acid, or salicylate of soda be given hypodermically, in doses of half a grain for each year of the patient's age, which may be exceeded and repeated every hour."

Dr. Cameron, M.P., as president of the Health Department of the Social Science Congress, 1881, in his address said, *inter alia*: "The natives of Senegal are often affected by a terrible disease, named by them *nelevan*. It takes 18 to 24 months to run its course; it causes acute pains, stiffness of limbs, glandular abscesses, and notably constant drowsiness, the sleep being heavy, with terrible dreams. The patient preserves his appetite to the last, but often loses his reason, and invariably dies. A French missionary, instructed by Dr. Déclat, used his medicines. The experiment was made in several cases, notably in one where the patient was in so advanced a stage of the disease that the missionary was only induced to try the treatment, that if it did no good it could do no possible harm; in every instance the result was success."

M. Pasteur, after long study, detected and directed the treatment which prevented the spread of the silkworm disease in France.

Dr. Koch isolated the little rod-like bacterium, which gives rise to splenic fever or plague disease in cattle. This disease costs the French nation about one million sterling annually. Dr. Klein showed pig typhoid or plague to be caused by microscopic organisms which he succeeded in cultivating. M. Toussant made a like discovery of the disease called fowl cholera. M. Pasteur has cultivated the poison of the latter in chicken soup, and after varied and long exposure to oxygen has *tamed* it, so that fowls injected with the attenuated form, or by taking it in their food, are preserved afterward from this disease. M. Pasteur has also discovered that animals inoculated with fowl cholera attenuation resisted splenic fever disease. The organisms of splenic fever have likewise been cultivated and *tamed* by him.

Ague has long been known to arise from exhalations from marshy ground. A bacillus has been found in the blood of those affected by it. Drs. Klebs and Tomassi Crudelli have investigated this subject with much success. This shows why it is that quinine, which is known to kill such organisms, is so invaluable a remedy, and preventive against malaria. Consumption has been usually considered a non-infective disease; it has been proved to be eminently infective. M. Toussant has been engaged investigating this subject, and quite recently he announced to the French Academy of Sciences that he had succeeded in isolating and cultivating the organism which gives rise to tuberculosis. Hydrophobia.—The series of discoveries announced by M. Pasteur and others have completely revolutionized our ideas of the nature of the disease.

Dr. T. Brown Henderson further gives the following directions for the use of salicylic acid, as recommended by Dr. Déclat and others, for the prevention and treatment of yellow fever, ague, cholera, etc.

SALICYLIC ACID.

Salicylic acid is the best preventive known. A dose should be taken night and morning; five grains are a small dose, ten grains a full dose.

Prepare as follows: Put a quarter of an ounce of salicylic acid into a clean common quart bottle. Add to it one gill of good rum or other spirit, afterward as much hot water as makes the bottle three-fourths full, and then fill it up with sweetened lime juice or any other agreeable liquid. (If wine is added it may be called antiseptic wine.) Half a glass will contain five grains or a small dose, and a full glass ten grains or a full dose, there being eleven ordinary wineglasses in an ordinary quart bottle. Shake the bottle before use.

Salicylic acid may be used as an injection into the bowels prepared as above, increasing the amount of water to dilute it to a small cupful. Dose as an injection by the bowels, five to ten grains. The same may be used without any spirit or sirup, as the above quantity is quite dissolved by even less hot water. It is better to prepare fresh each time, and use before quite cold, or use a solution of salicylate of soda, the carbolate of ammonia, or the sulpho-carbolate.

CARBOLIC ACID.

Carbolic acid is of the same nature as salicylic acid. As a preventive, the minimum dose is one drop (night and morning), and the full dose two drops.

Prepare as follows: To twenty minims by measure, or twenty-four drops, put into an ordinary quart bottle, add a half or three-fourths of water, and fill up the bottle with sirup made by boiling sugar in water. Half a common wineglassful or two tablespoonfuls contain one drop. In drinking it more water may be added according to taste. If an epidemic is near, a wineglassful may be taken in a tumbler of water soon after or before food, two or three times a day.

The subcutaneous treatment is as follows: Dissolve twenty drops or eighteen minims by measure of carbolic acid in four ounces of pure steam water (hot), shake it and it is ready for use.

Directions for subcutaneous injection: The needle having been adjusted, draw up about 100 drops into the syringe. Holding the needle and syringe like a pen, pinch up the skin of the arm, thigh, abdomen, or chest, and having selected a flaccid part, insert the needle under the skin, well into the cellular or fatty tissue, *below* the skin and *above* the flesh. Move the syringe from side to side, half or three-fourths of an inch. Withdraw it a little, and again move the needle as above, so as to make room for the liquid, then inject with a slow steady pressure. Withdraw the needle, and at once put the point of the finger where the prick was made. Keep it there a minute or two, then touch the prick with a little collodion on a stick or the end of a match. A fresh part to be selected for each successive injection. This operation is very simple, and there is no danger attending it. An arm or leg is usually selected. The injection is to be simply under the skin, into the fatty tissue. After each injection the syringe should be cleaned, by drawing up water through the needle a few times. Should any impurity or sediment be found in any of the solutions for subcutaneous injection, it should be passed through a cotton cloth. The medicines suitable for use are carbolic acid, the solution of carbolate of ammonia, which is in flasks prepared in France as phenate of ammonia by Dr. Déclat, and the solution of sulpho-carbolate of ammonia.

SULPHO-CARBOLATE OF AMMONIA.

Of sulpho-carbolate of ammonia about ten grains are a dose. Prepare thus: Dissolve a quarter of an ounce in two ounces of distilled water—steam water—hot or cold. Of this solution 100 drops, or rather over 1½ teaspoonfuls are the above dose. This medicine is also suitable for use by the stomach, or, diluted with three or four ounces of cold water (a small teacupful), as an injection by the bowels.

When seized by yellow fever or cholera there are three channels by which the anti-fermentative treatment should be used: 1. By the mouth; 2. By subcutaneous injections; 3. By the bowels.

1. By the mouth, salicylic acid, carbolic acid, salicylate of soda, and carbolate of ammonia may be administered.

2. By subcutaneous injections, solution of carbolate of ammonia, carbolic acid, and sulpho-carbolate of ammonia.

3. Injections by the bowels, consisting of a small teacupful of a cold injection containing the same quantity of the medicine as is given by the mouth.

Since the above was written I am glad to learn that phenate, or carbolate of ammonia, can be procured from Messrs. Burgoyne, Burbidge, Cyriax & Farries, at a moderate price. It should be used as directed for preparing the sulpho-carbo-

late of ammonia. Failing either of these medicines I would use in the same way and strength a solution of salicylate of soda.

The first four doses should be of carbolic acid and carbolate of ammonia, alternately, and the fifth dose of the sulpho carbolate of ammonia, then repeat as above, the interval between each injection being one, one and a half, two, three, or four hours, according to the urgency of the symptoms and the effect produced, the age and strength of the patient, etc., being considered.

Injections by the bowels in a severe case are to be used diligently, in the following order. Sulpho-carbolate of ammonia, salicylic acid, carbolate of ammonia, and carbolic acid.

In order to check an attack, it would be quite proper to use the three channels for the medicines simultaneously, or within a very short time of each other. On the complaint not yielding to the treatment readily, it would be right to repeat the subcutaneous injection and the bowel injection in one or two hours. As the complaint became subdued two of the channels at least ought to be kept under treatment.

Steam water is the purest and best for every purpose. It can be made pleasant for drinking by aerating it, which is done by pouring it from vessel to vessel so as to make it take up air. This should not, however, be done in the sick room.

In the treatment of all fevers, when the temperature rises to 104° F., or thereby, the iced blanket is of great service in lowering temperature and promoting cure. The manner of using it is as follows: Let two pieces of flannel or blanket be used, so large that each, when folded fourfold, may cover the chest, abdomen, and sides, the night-dress having been rolled up to the neck so as to be kept dry. One of the two pieces of flannel or blanket is to be wrung nearly dry, out of the cold or iced water, and laid on the patient, covering him up for one or two minutes. Meanwhile the other piece of flannel is in the cold water. Let it be quickly wrung out and applied as above. The flannel should feel cold when taken off the patient. Continue this treatment till the temperature is lowered to 98° or less, say for a quarter of an hour, repeating it in two hours if necessary.—*Monthly Magazine.*

ON THE DETERMINATION OF SEX IN GENERATION.

By T. M. HARRIS, M.D.*

THE subject of the determination of sex in generation has long claimed the attention of physiologists, and although there have been several theories advanced in regard to it, yet we are compelled to say that it is a subject of investigation on which we have not, as yet, attained to any certain knowledge. It is well understood that in successful coition the ovum of the female is impregnated by the semen of the male; and that in this union of the germinal elements is involved the development of a new being after the kind of the procreating pair, either male or female. Now, when we reflect that the continuation of the race demands the two sexes; and also that the best development of the race demands that they should be found in a nearly equal ratio, we are bound to conclude that the sex of the new being is determined by some law; and that this law, or determining cause, is intended to secure the necessary uniformity of ratio in the sexes. It is not my purpose, in this paper, to advance, dogmatically, any theory; but starting from the above proposition, to call the attention of the members of this society to a theory that has been advanced, that has about it as much of the air of probability as any that I have seen, in order to elicit observation that may verify or disprove its correctness. The theory is this: That the sexually determining force is found in the excess of sexual desire in the male or the female parent, in the act of coition.

If the passion or sexual desire of the male is greater than that of the female, the result will be a female offspring; and, on the other hand, if the sexual desire of the female be stronger at the time of conception than is that of the male, the result will be the procreation of a male. In favor of this theory it has been argued that in case the uniformity of ratio in the sexes should be broken in a very marked degree, so that the excess of either males or females would be very great, the necessity would manifestly be the restoration of this ratio; and so if the excess should be on the part of the female sex, it would naturally result that the passion or sexual desire of the female, in the procreative act, would be stronger than that of the male; and that by the sexually determining force of this stronger passion a male would be produced, thus tending to the restoration of the equilibrium of the sexes; and *vice versa*.

Having placed before you, as succinctly as possible, this theory, I will now proceed to observe that it can only be verified or disproved by a long course of careful observation; and I beg leave to say that I deem the subject of sufficient importance to justify us in giving to it the careful attention that will enable us to claim its justification or rejection.

Being a breeder of Jersey cattle, my attention has been turned to this subject by the pecuniary interest involved. It is especially the case with this breed of cattle, that the males, as a rule, possess but little value, while the females are very valuable. Under these circumstances we naturally desire the propagation of females, and feel a certain degree of disappointment and dissatisfaction when we find a male where we had hoped to secure a female calf. We naturally wish that we knew how to secure a different result; in other words, that we knew how to determine the sex in breeding.

If the above theory be correct, we have the whole matter in our own hands; for we may keep such a number of males that they may never be overworked; in addition to this, we may keep them in such a condition of flesh and blood, by proper feeding and care, that they shall always be warm, strong, and potent in the sexual act.

We may then make assurance doubly sure, by keeping the female from the male until she shall have passed the meridian of sexual excitement, and her desires for the male shall have begun to abate. When under all these conditions, if the above theory be the correct one, we should always secure a heifer calf. And having succeeded in this a sufficient number of times to give us confidence in the theory, we might still further verify it by changing all the conditions, when we ought to have the opposite result. I trust I have now shown that this theory, which I do not claim as my own, but which I am now engaged in verifying as above, is susceptible of demonstration, if it be the correct one. My observations have not as yet been very extensive; but I must say they justify me in further trials, nay, even in putting it fully to the test. I cannot expect the members of this society, who, unlike myself, have no pecuniary interest at stake, to be interested as much in this subject as I am; but yet, as a matter of scientific research, it is not devoid of interest, and might well challenge your observation. In regard to the human race, we can well see how the contingencies and vicissitudes of life would naturally tend to the equilibrium of the sexes. The ordination of marriage securing the propagation of the race in families and from pairs, we can well see how the varying conditions of the physiological state, both in the male and the female, under all the vicissitudes of life, should tend to keep the sexes pretty nearly equal in numbers. But there are notable exceptions to this rule.

Occasionally we find a family in which all the children are boys, and again another in which all are girls, and in both cases running through the usual number of children for a family. Now here is a field for the verifying or disproving of our theory. If it be correct, we should find, upon a careful scrutiny of the parents, that the family of boys should have a mother of strong sexual propensities, or what we would call an amorous temperament, while the father should be lymphatic and sluggish. Of course, the state of health of the parents should also be taken into the account. And so, in the family where we find the children all girls, the opposite conditions should obtain with the parents. My observations thus far, in this department, have rather tended to confirm the above theory. Again, we sometimes see a man decidedly past the meridian of life, and whose physical vigor is on the decline, marry a young, or a comparatively young and vigorous woman; and in this case my observations are confirmatory of this theory, the children from such a marriage being almost uniformly boys. The case of illegitimate children might also be observed in its bearing on this subject, as the male, in this case, is usually the aggressor—young, vigorous, and impelled by an overbearing, imperious passion. Of course, to make our observations perfect in this case, we should be able to take into the account the actual physical condition, age, temperament, state of health, etc., of both the parents.

Let me now ask you, gentlemen, at the conclusion of this paper, to give some attention, as you may have opportunity, to the subject of it. Let us have it on the list of subjects for investigation, and, from time to time, let us see what bearing the facts we may be able to observe and collect may have, either toward its confirmation or overthrow.

* Read before the Ritchie County, West Virginia Medical Society.

CAUSE OF MILK SICKNESS.

To the Editor of the Scientific American:

I have the honor to report that I have discovered the cause of the famous "milk sickness," so well known and yet its cause so little understood. That as I was going through the "bowels of the earth," with the blow pipe, in search of ores and metals, I also came across the original cause of said sickness, and feel able to prove that it is from the volatile metals in beds and veins in the vicinity, and having for their ringleader *arsenic* and *sulphur*. Miners and scientific men and physicians are aware how that arsenic, tellurium, lead, zinc, and such metals are volatile, and that all of their oxides are irritant poisons; that when taken into the animal system by way of the lungs or stomach, they are capable of producing violent vomiting, great debility, tremors of the limbs, cramps, pains, etc.; and are they not the very symptoms of milk sickness? In districts infested with milk sickness, these volatile metals always abound compounded more or less with sulphur, and as arsenic is the most volatile and abundant, it is most to be dreaded. When sulphides containing arsenic are in the soil, exposed to the weather and heat of the sun, they are decomposed and converted into sulphuric acid and arsenous acid; their oxides, soluble in rain water, and at a temperature not much above 32° Fah., begin to vaporize and ascend up into the air; but when rain water is suffered to stand upon them in fields or stagnant river beds, raised to a temperature of 125° under the boiling heat of the sun, liquid arsenic and sulphuric acid is drawn out, to be drunk by the first thirsty ox that comes along, or it mounts the breeze and floats the air to be breathed by human beings, corroding the nasal passage into catarrh and the lungs into bronchitis and consumption, corroding and crumbling the teeth as they go, and in different ways find access into the animal system. If the country in such places could be kept dry, no milk sickness would really exist. With a view to its removal from such districts, let all the farmers and landholders therein join hands and see that no intermediate lands are left undrained; let the waters run right off as fast as they fall. Let county commissioners make vastly more big ditches for outlets—it will cost more in taxes, but less in doctors' bills. Let parties digging wells wall up with good limestone, instead of using the same "nigger heads" dug out, as they are ores to be avoided, and cement their walls from top to bottom, so as to keep out all surface water. Then remove from the yard near the house all decomposing ores. The lands so drained will then be in a shape to increase our wealth, and we shall soon become a hale, happy, and wealthy people.

ELLIOT EBERLY.

Portage, Wood Co., Ohio, March 23, 1882.

"HOANG NAN," A NEW CHINESE REMEDY.

THE learned Abbé Lesserteur has forwarded to the French Geographical Society a pamphlet on the "Hoang Nan," a plant used in Tonquin in cases of hydrophobia, leprosy, snake bite, etc. In presenting this pamphlet to the Geographical Society, M. Romanet du Caillot said that the new remedy was supposed to be an effectual cure for hydrophobia. The plant in question has been carefully classified by M. Pierre de Saiguon, the botanist. He placed it among the strychniæ, and is of opinion that it may prove useful to tropical explorers.

The traveler, Abbé Lesserteur, gives an account of the cure, in Tonquin, of the bite of the black viper by means of this plant, and two cases of the cure of the bite of the *cobra de capello* in India; the bite of the cobra, he asserts, means simply death within half an hour.

M. Feron, a French missionary in India, who appears to have some experience of the new remedy, has written that a boy of 17 years of age was bitten on the heel by a cobra. In a few minutes the lad's leg swelled up as far as the thigh, and in less than ten minutes his sight was completely gone.

The first three pills restored his sight, and reduced the swelling of the leg to below the knee; two more reduced it to the sole of the foot. At the end of half an hour no pain was felt except that occasioned by the lesion of the *tendon Achilles*, and this pain disappeared as the wound proceeded to cicatrization.

CONSUMPTION.

By PROF. TYNDALL.

ON March 24, 1882, an address of very serious public import was delivered by Dr. Koch before the Physiological Society of Berlin. It touches a question in which we are all at present interested—that of experimental physiology—and I may, therefore, be permitted to give some account of it in the *Times*. The address, a copy of which has been courteously sent to me by its author, is entitled "The Etiology of Tubercular Disease." Koch first made himself known by the penetration, skill, and thoroughness of his researches on the contagium of splenic fever. By a process of inoculation and infection he traced this terrible parasite through all its stages of development and through its various modes of action. This masterly investigation caused the young physician to be transferred from a modest country practice, in the neighborhood of Breslau, to the post of Government Adviser in the Imperial Health Department of Berlin.

From this department has lately issued a most important series of investigations on the etiology of infective disorders. Koch's last inquiry deals with a disease which, in point of mortality, stands at the head of them all. If, he says, the seriousness of a malady be measured by the number of its victims, then the most dreaded pests which have hitherto ravaged the world—plague and cholera included—must stand far behind the one now under consideration. Koch makes the startling statement that one-seventh of the deaths of the human race are due to tubercular disease, while fully one-third of those who die in active middle age are carried off by the same cause. Prior to Koch it had been placed beyond doubt that the disease was *communicable;* and the aim of the Berlin physician has been to determine the precise character of the contagium which previous experiments on inoculation and inhalation had proved to be capable of indefinite transfer and reproduction. He subjected the diseased organs of a great number of men and animals to microscopic examination, and found, in all cases, the tubercles infested with a minute, rod-shaped parasite, which, by means of a special dye, he differentiated from the surrounding tissue. It was, he says, in the highest degree impressive to observe in the center of the tubercle cell the minute organism which had created it. Transferring directly, by inoculation, the tuberculous matter from diseased animals to healthy ones, he in every instance reproduced the disease. To meet the objection that it was not the parasite itself, but some virus in which it was embedded in the diseased organ, that was the real contagium, he cultivated his *bacilli* artificially, for long periods of time, and through many successive generations. With a speck of matter, for example, from a tuberculous human lung, he infected a substance prepared, after much trial, by himself, with the view of affording nutriment to the parasite. Here he permitted it to grow and multiply. From this new generation he took a minute sample and infected therewith fresh nutritive matter, thus producing another brood. Generation after generation of *bacilli* were developed in this way without the intervention of disease. At the end of the process, which sometimes embraced successive cultivations extending over half a year, the purified *bacilli* were introduced into the circulation of healthy animals of various kinds. In every case inoculation was followed by the reproduction and spread of the parasite and the generation of the original disease.

Permit me to give a further, though still brief and sketchy account of Koch's experiments. Of six guinea pigs, all in good health, four were inoculated with *bacilli* derived originally from a human lung, which, in fifty-four days, had produced five successive generations. Two of six animals were not infected. In every one of the infected cases the guinea pig sickened and lost flesh. After thirty-two days one of them died, and after thirty-five days the remaining five were killed and examined. In the guinea pig that died, and in the three remaining infected ones, strongly pronounced tubercular disease had set in. Spleen, liver, and lungs were found filled with tubercles; while in the two uninfected animals no trace of the disease was observed. In a second experiment, six out of eight guinea pigs were inoculated with cultivated *bacilli*, derived originally from the tuberculous lung of a monkey, bred and re-bred for ninety-five days, until eight generations had been produced. Every one of these animals was attacked, while the two uninfected guinea pigs remained perfectly healthy. Similar experiments were made with cats, rabbits, rats, mice, and other animals, and, without exception, it was found that the injection of the parasite into the animal system was followed by decided, and, in most cases, virulent tubercular disease.

In the cases thus far mentioned inoculation had been effected in the abdomen. The place of inoculation was afterward changed to the aqueous humor of the eye. Three rabbits received each a speck of *bacillus* culture, derived originally from a human lung affected with pneumonia. Eighty-nine days had been devoted to the culture of the organism. The infected rabbits rapidly lost flesh, and after twenty-five days were killed and examined. The lungs of every one of them were found charged with tubercles. Of three other rabbits, one received an injection of pure blood serum in the aqueous humor of the eye, while the other two were infected, in a similar way, with the same serum, containing *bacilli* derived originally from a diseased lung, and subjected to ninety-one days' cultivation. After twenty-eight days, the rabbits were killed. The one which had received an injection of pure serum was found perfectly healthy, while the lungs of the two others were found overspread with tubercles.

Other experiments are recorded in this admirable essay, from which the weightiest practical conclusions may be drawn. Koch determines the limits of temperature between which the tubercle *bacillus* can develop and multiply. The *minimum* temperature he finds to be 86° Fahrenheit, and the *maximum* 104°. He concludes that, unlike the *bacillus anthracis* of splenic fever, which can flourish freely outside the animal body, in the temperate zone animal warmth is necessary for the propagation of the newly discovered organism. In a vast number of cases Koch has examined the matter expectorated from the lungs of persons affected with phthisis, and found in it swarms of *bacilli*, while in matter expectorated from the lungs of persons not thus afflicted he has never found the organism. The expectorated matter in the former cases was highly infective, nor did *drying* destroy its virulence. Guinea pigs infected with expectorated matter which had been kept dry for two, four, and eight weeks respectively were smitten with tubercular disease quite as virulent as that produced by fresh expectoration. Koch points to the grave danger of inhaling air in which particles of the dried sputa of consumptive patients mingles with dust of other kinds.

It would be mere impertinence on my part to draw the obvious moral from these experiments. In no other conceivable way than that pursued by Koch could the true char-

acter of the most destructive malady by which humanity is now assailed be determined. And, however noisy the fanaticism of the moment may be, the common sense of Englishmen will not, in the long run, permit it to enact cruelty in the name of tenderness, or to debar us from the light and leading of such investigations as that which is here so imperfectly described.

PRACTICAL NOTES.

By HANS M. WILDER.

Sirups.—When sirups are made they are generally poured into the stock bottles or stone jugs while hot, or at least quite warm; the containers are then stoppered and put aside. Now, it often happens with many sirups, particularly when the warm weather sets in, that they sour or ferment. This can in a great measure be prevented by giving the filled sirup bottles, etc., a good shaking up when perfectly cold.

The rationale is: When we pour a hot liquid (or, for the matter of that, a hot solid) into a receptacle and stopper, vapor will arise, collect over the surface of the contents, and on cooling be thrown down as water, which floats on top of the dense sirup, mixes by diffusion with some of it, and thus forms a weak saccharine solution, which, as may be expected, does not keep very long before it spoils, and eventually spoils the remainder.

By observing the precaution of shaking the containers when cold the watery layer will mix with the remainder, and thus form a sirup of normal consistence throughout.

Milk.—Although highly beneficial, not only as an article of daily food, but also, for most invalids, physicians are debarred in many instances from its help through the patients' inability of digesting it. Physicians pay generally too little attention to the temperature of the food which their patients take; if milk be warmed, with constant stirring, to 95 to 100° F., it is surprisingly quickly assimilated.

The writer knows, from his own experience, that one pint of milk, of the ordinary temperature, taken at nine A.M., completely spoils his appetite for the noonday meal, while, when the milk has been warmed to about the temperature of the blood, he gets hungry enough at eleven A.M.

Quinia.—Among all the different vehicles recommended to mask the bitter taste of quinia none is better than our old acquaintance, licorice. Although the usual way is to make a "shake well" mixture with fluid extract of licorice, or an aromatic elixir of the same, it is once in a while prescribed as a powder mixed with powdered extract of licorice. This covers the taste well enough, but the bitterness is still perceptible. I have found that by combining aromatics with it the bitter taste is pleasantly covered.

I have for some time kept ready a pulvis glycyrrhizæ aromaticus:

Pulv. aromat.	ʒ ij.
" ext. glycyrrhiz.	ʒ vj.
Ammon. carbon.	gr. xv. Mix,

which is mixed with quinia in the proportion of four times its weight (about twice or thrice its bulk). Patients declare themselves very well pleased, and children take it readily. Incidentally I make remark that there is a marked difference in the powdered extract of licorice as found in the market; some produce no more impression on the tongue than a mixture of about equal parts of gum arabic and licorice would do.

Pills of Carbonate of Iron.—Pills made from protosulphate of iron and carbonate of potassium (usually equal parts) are a stumbling block to not a few pharmacists. By proceeding according to Prof. J. M. Maisch, as follows, all difficulties vanish:

Two drachms of each of the above named salts are rubbed together till the mass not only acquires a brown color, but also forms quite a pasty consistence. Add powdered tragacanth half a drachm, mix well and let stand for ten to fifteen minutes. The mass will now require the addition of but a few drops (five to six) of simple sirup to become plastic.—*American Journal of Pharmacy.*

THE OIL OF D'ANDA-ASSU AND OF LA JOHANASEINE.

D'ANDA-ASSU is of the class crotonees—of the family of euphorbiaceæ—of the genus Johaneseiæ princeps; in different parts of Brazil it is known under the name of coco purgatif. It is a tall beautiful tree, with branches opening to the sun, with fruit six to eight centimeters long. M. Oliveria, of Rio Janeiro, has analyzed the juice of the tree, and has given it the name of Johanascine. This substance is slightly soluble in water and in alcohol, and is soluble in chloroform, benzine, ether, and sulphide of carbon. Dr. Corety conducts his experiments with the preparation of M. Oliveria, but, contrary to the opinion of many Brazilian physicians, finds that this salt has no poisonous effects.

As to the oil, Dr. Jones, Professor in the Faculty of Rio Janeiro, experimented on a patient having cirrhosis of the liver. The dose, two teaspoonfuls, produced six alvine evacuations. Several other physicians obtained excellent results.

Dr. Castro concludes as follows:

1. That the purgative effect of D'anda-assu is obtained in three or four hours, and with several evacuations.
2. That it produces no intestinal irritation.
3. That it can be employed in all cases where castor oil is used, over which it has advantages.
   a. That the dose is one-third, or one-third less.
   b. That it has no repugnant odor like castor oil.
   c. That it does not adhere to the mouth as castor oil does.
   d. That one grain of the oil has ten times the strength of castor oil.—*Arct. de Rio Janeiro—Journal de Therapeutique.*

NITRATE OF ETHYL FOR DISINFECTING PURPOSES.

A WRITER in a foreign medical journal proposes the disinfection of hospital wards and sick chambers by the vapors of nitrite of ethyl, which are diffused in the atmosphere from a mixture of alcohol and nitric acid. These may be put in saucers or porcelain capsules, and heated over hot water. It has, however, been necessary to alter the proportion of the ingredients ordinarily used in the production of these ethers in order to obviate the development of acid vapors. The following mixture covers the difficulty, and is an effective disinfectant:

Alcohol at 90°	4 parts.
Nitric acid, 36°	1 "

[NATURE.]

THE GREAT NEBULA IN ANDROMEDA.

FEW objects in the heavens have been treated with such unmerited neglect as this which has not inaptly been termed the Queen of the Nebulæ. Notwithstanding its enormous magnitude, spreading out, as followed by the Harvard 15-inch achromatic, to 2½° in length (according to Bond—Trouvelot gives more), with a breadth of upwards of 1°; and its conspicuous brightness, readily perceptible with the naked eye, it has received little comparative notice. The reason probably may be the pertinacity with which it has hitherto resisted all inquiry, and defied the efforts of the most powerfully armed investigation; so that it seems to have been left on one side, as too unpromising for more than casual inspection. This, however, bears the character of a premature conclusion. Direct examination by the most powerful telescopes has done very little to solve the mystery of its nature. The reply extorted by the spectroscope is but partially intelligible. But we must not therefore despond. The negative or ambiguous results hitherto obtained do not preclude—on the other hand they rather invite—attempts of a different kind. If again defeated, we are only where we were before. If in any measure successful, we may indeed find the mystery only increased by partial solution; but such, after all, is the progress and the limit of all earthly knowledge. An obvious line of inquiry presents itself in the present instance, which seems not to have been adverted to in modern times—the possible evidence of variation either in form or brightness; and the following notices, neither as exhaustive nor as minute as the subject would otherwise admit, have been chiefly put together with this view.

The history of this nebula, which includes the ancient evidence, such as it is, of variation, is in brief as follows:

The first mention of it, according to the late Prof. G. P. Bond, the eminent observer at Harvard College, Cambridge, U. S. America, to whose memoir we shall be indebted for a considerable portion of our materials, occurs in an ancient star-catalogue with charts, supposed to date back as far as the close of the tenth century,* where it is represented of an oval form. Its previous omission in ancient catalogues is more easily accounted for than the remarkable silence of Tycho Brahe and Bayer. Marius (Mayer) in 1612 was the first to apply to it the recently invented telescope; his description of whitish rays, brightening to a dull and pallid center, like a candle shining through horn, agrees sufficiently with its present aspect in a similar instrument. It again attracted notice in 1664, in consequence of the vicinity of a comet, for one of which bodies it has been several times mistaken, and it has never since been lost sight of, though Bouillaud thought its brightness variable between 1664 and 1666. In 1676 Kirch was of a similar opinion. Cassini in 1740 described it somewhat unaccountably as nearly triangular. Mairan in 1754 indorsed the description of Marius. Le Gentil in 1749 observed it circular and of uniform density; but oval, with central condensation, in 1757–1758; and, from a consideration of all the known observations, believed it variable, without, however, being insensible to the differences arising from the inequality of optical means. Messier, on the other hand, whose familiarity with cometary phenomena rendered him a peculiarly competent witness, perceived no variation in a form similar to the present during the fifteen years ending in 1771; and since that time none appears to have been suggested. In fact, when we bear in mind the imperfection of the ancient telescopes, and the known differences of vision and of judgment, by no means confined to earlier periods, we shall probably be of opinion that the evidence of change, though not to be rashly set aside, is far from amounting to demonstration.

We must, however, pass on to more recent times. Sir W. Herschel described it in 1785 as 1½° long, and 16′ broad where narrowest; his son in 1826 noted that its brightness, gradually augmenting from the oval circumference, receives a sudden increase at the center, so as to form a nucleus, but without any distinct outline, of 10 seconds or 12 seconds in diameter. The whole light he describes as of the most perfectly milky and absolutely irresolvable character, without the slightest tendency to the flocculent appearance of the Great Nebula in Orion. Ten years afterward Lamont, with the Munich refractor of 11·2 (?English) inches, and a power of 1,200, found the nucleus, of about 7 seconds, longish in form, composed of very minute granulations, but without resolution.

Thus matters stood till July, 1847, when, soon after its erection, the great Merz achromatic of Harvard College was brought to bear upon it, with the confirmation of the almost star-like nucleus, but, owing no doubt to the unfavorable background of the summer sky, it was not till September 14 that the two dark rifts or canals were detected, which form so strange and peculiar a feature in this grand object. But no resolution was attained. It was estimated that owing to the light and sharpness of this admirable instrument upwards of 1,500 stars were visible within the limits of the nebulosity, without the least apparent connection with it. And on which side they may lie who will presume to say?

We may now give a reduction from the drawing of Prof. G. P. Bond, adequate to our present purpose, though, from the difference of material, far inferior in delicacy to the original steel engraving. Great pains were taken in delineation, and numerous measures were obtained from the divided circles of the instrument; but an important admission of his must be borne in mind as to possible error in the comparative brightness of the different regions.

The drawing includes, it will be observed, two bright patches, one on either side of the grand central mass, but each involved in its diffusion, and therefore presumably, though not demonstrably, a part of the same complex structure. The more distant one below to the left, or north-preceding (for our diagrams give the inverted or telescopic view), was discovered by Caroline Herschel in 1783, and is known as HV 18, or No. 105 in the General Catalogue of Nebulæ. The other attendant, pointed out by Le Gentil, No. 32 in Messier's, 117 in the General Catalogue, is much smaller, but brighter, and of a circular form. The interior canal is the longer and more distinct, 1¼ minutes broad, very uniform for about half a degree, with straight, sharp, and slightly diverging sides; further north it begins to bend, and becomes fainter and less regular. The second is about 4 minutes distant from it, shorter and less distinct, as occurring in fainter light. The two rifts are inclined at an angle of about 3 degrees, opening toward the north, and their sides seem to have a common point of divergence; and in several places along the course of the axis, which was distinctly marked, there were gatherings of brighter knots and darker openings.

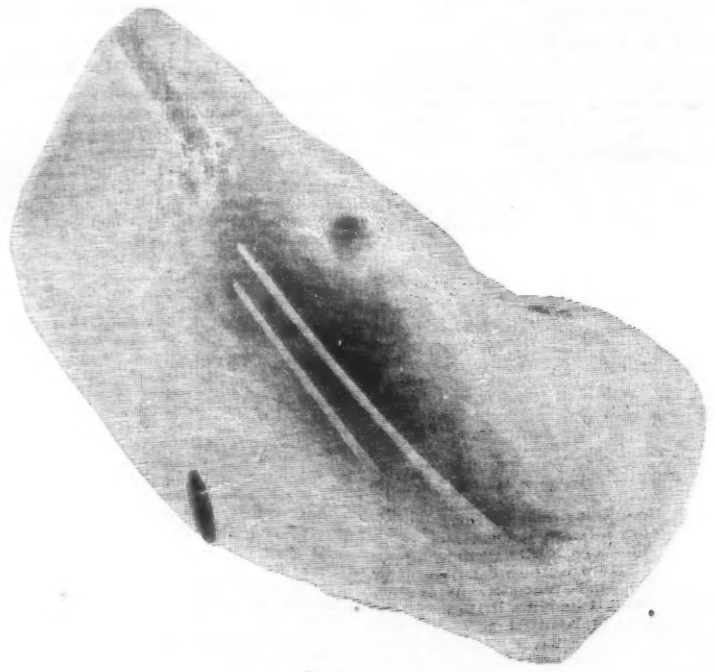


FIG. 1.—BOND, 1847.

We next give a copy, reduced to the same scale, of a beautiful drawing, with the same telescope by Trouvelot, in 1874; omitting, as unimportant for our present purpose, a large diffusion of faint nebulosity beyond the south extremity of Bond's figure. Of this drawing, however, it is expressly noted that it only gives a good general idea, and must be considered not as a map, but a picture.

Lastly, we shall add a sketch obligingly made for the express purpose of this paper by the Rev. Jevon J Muschamp Perry, on December 14, 1881, with his great 18¼ inch silvered glass reflector by Calver, an instrument of such perfection as to admit of not only separation, but measurement of that excessively difficult pair γ^2 Andromedæ, the position of which Mr. Perry found, on December 10, 1881, by two measurements with a power of 600, 95 degrees and 96 degrees, with a distance of 0·3 second.* It must be borne in mind that this is not, like Bond's and probably Trouvelot's drawings, a combination of results, but a single sketch, according, however, precisely with one taken on a previous night; and it is no less material to add that subsequent examination in clearer air revealed, as might be expected from the light-grasp of such an instrument, a much greater extension of nebulosity in every direction, equal, as it would seem, to that shown in the American observations.

In these two views, taken with the same instrument after an interval of twenty-seven years, and a third, six years later, with a telescope of fairly equivalent power, we have before us the materials of an interesting comparison. The general similarity is obvious; but there are variations which it may not be well to ignore. One is, the form of the principal mass of light, spindle shaped in the earlier, globular in the two later drawings. This difference, while reminding us of the ancient variations

* The Persian astronomer Sûfi, Flammarion informs us, referred to it about the same period as a well-known object.

* The agreement is remarkable, in so close an object, with one of the Washington measures, 1880·639, 95·8 degrees, 0·35 second; their average for three years being ·01 degrees, 0·358 second.

of Le Gentil, may possibly not imply much, where no distinct outline is presented to rectify the judgment of the eye. But we have something more tangible in the length and form of the canals. Here, assuming equal care on the part of Trouvelot in designing, with that claimed by Bond both in delineation and description, we seem to have indications of change. It is true that Bond's account of the outer or shorter canal, as commencing a few minutes *n p* the other, does not altogether agree with his drawing; but this is not the sole instance of confused "orientation" in his memoir; and at any rate he describes its

FIG. 2.—TROUVELOT, 1874.

commencement as only 4 minutes of space distant from the other. Trouvelot, as will be seen, has extended it much further *s p;* and should it be objected that this slenderer termination may have escaped the eye of Bond, it is curious to find it strongly and independently confirmed by Perry in two sketches on different nights, and by his express statement that "the *p* rift extends further than the *f* rift on the southern side." The greater breadth which he has given in each sketch to both canals is also worthy of notice. Another point of disagreement between Bond and Trouvelot occurs in the form of the longer canal: the "perfectly straight, suddenly terminated, and slightly diverging" sides, as far as the nucleus, of Bond's description, would have been discovered. And latterly, whether from decay of visual power, or want of purer air, I have failed to detect them. But the general result is unmistakable. Either Bond's drawing must have exaggerated—and that materially—the light which they traverse; or that light must have since faded. The latter it must be owned is not probable. Yet his figure is fairly supported by his words, where he gives both canals near the nucleus as "beautifully distinct," and the light between them two-thirds as bright as on the inner side of the longer one, and his design makes both rifts cleave, not as now, the feeble diffusion, but the great mass, not far from its very heart. On the other hand it must be admitted that probably at a not much later date, Lord Rosse's

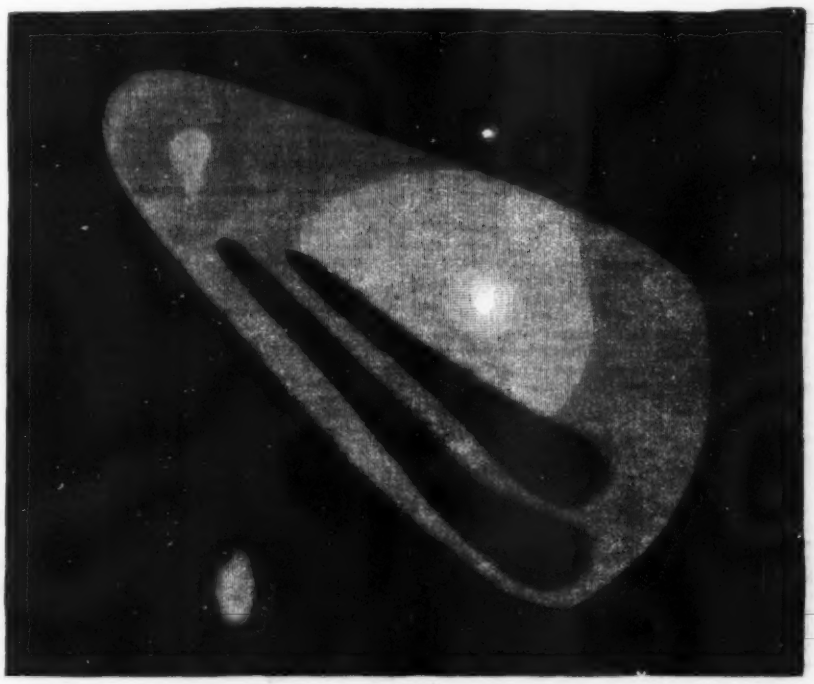


FIG. 3.—PERRY, 1881.

tion, confirmatory of his drawing, according ill with the sinuous direction which Trouvelot has shown.

This may suffice for the collation of the results obtained by great instruments. But a comparison yet remains with the appearance in smaller telescopes; and it will be found deserving of attention. Let our aperture be restricted to 5 inches achromatic, or an equivalent light in a reflector; then, with ordinary vision and customary skies, the three salient points, the great center, Le Gentil's ball, and three-foot speculum showed a much greater contrast between the opposite sides of that canal; and Trouvelot comes much nearer to the present aspect of things; so that nothing very satisfactory can be deduced here. The case, however, may seem stronger with regard to Caroline Herschel's nebula. There are discrepancies in the earlier values of its light. Her brother called it "pretty faint" with an area of $30' \times 12'$, proving that he included with it much of the great nebula. His son, reducing it to $15' \times 7'$, found it "pretty bright," though it stands as "very bright" in the General Catalogue. Bond shows it of a brilliancy superior to all but the light near the great nucleus and the center of Le Gentil's ball. The Earl of Rosse, with the six-foot mirror in 1876, complains of this delineation as "far too bright and sharply defined." Trouvelot again, with a softer general effect, has a small center as bright as Bond; and this may perhaps be the nucleus faintly suspected by Sir John Herschel, and described by Lord Rosse, in 1855, as bright and sharp; while the cautious and accurate d'Arrest (1861–67), using an eleven-inch object glass, and giving its size $12' \times 2\frac{1}{2}'$, speaks of it as only moderately bright, much more so toward the center, but without a genuine nucleus. These details, needless and tedious as they may possibly at first appear, are introduced chiefly from their bearing on our present inquiry as to the probability of change, but in some measure as illustrative of the uncertainty that hangs about such observations. Every one may not be aware of the breadth of margin required, where there is no distinct outline, and faint diffusions fade out of all but the purest skies, and dilate and shrink by turns under the anxious gaze, and estimates of brightness are precarious, and artistic talent is often dissociated from the observer's skill. But after all allowances there can be no doubt that the existing aspect of this (Miss Herschel's) nebula, with moderate telescopes, is much less reconcilable with the designs of Bond and Trouvelot than might have been expected.

We can neither at present push this line of inquiry further, nor say that it has been very successful. Had it yielded us distinct evidence of change either in form or brightness, it must, of course, have been accepted as decisive against a stellar constitution; but we have only met with such probabilities as invite close and long research; and it was with a view of stimulating such research that the present paper was undertaken. A few more remarks may be permitted to render it less incomplete.

We stated originally that no resolution has ever been effected. This seems undoubted as to the grand mass.* The Earl of Rosse had indeed thought such development approaching with the three-foot mirror, but only from an aspect presented also by the Dumb-bell and Ring nebulæ, since known to be gaseous; and the six-foot giant broke down in its turn; and Newcomb has remarked that "in the most powerful telescopes the light fades away so softly and gradually that no such thing as resolution into stars seems possible. Indeed, it looks less resolvable and more like a gas in the largest telescopes than in those of moderate size." But there is less unanimity as to the two companions. Bond expressly states that under high powers, one hundred and five appeared to be a coarse cluster of stars. The six-foot at Parsonstown, on the contrary, effected no such result; and we may remember that Bond had imagined momentary resolution in the Orion nebula. As to the bright ball, the Herschels and Bond lay no claim to success; the latter only remarking that the field preceding it contained multitudes of very small stars on a very even milky nebulous ground. Lord Rosse's three-foot gave it resolvable; the six-foot was silent.

D'Arrest once says: "Nucleus stellatus circa medium;" at other times finds a nucleus equaling a nine or ten magnitude star.† It has been thought resolvable by Buffham, and I believe by Key, and has certainly that aspect in my nine and one-third inch speculum. But even were these two companions found to be of a starry nature, their connection with the principal mass (though in the case of one hundred and five supposed by Bond to be indicated by a line of stars) would yet remain to be demonstrated. It may be improbable, but it is not impossible, that each may be a case of mere optical juxtaposition.

The telescope has comparatively failed. But the spectroscope remains—an instrument as superior in analytical as it is inferior in optical power. And here we get some kind of reply; but still, except in one respect, an indecisive one. It precludes at once the idea of a simple gaseous condition such as that of the Ring nebula, or the Dumb-bell, or the wonder in Orion; d'Arrest complains indeed of the feebleness of the principal spectrum; but all the three are continuous, as from stars. And yet they are peculiar, being deficient at the red end; at least, this is expressly stated as to the central mass and the little ball. This peculiarity reappears elsewhere, not only among others in the beautiful nebulæ M 81 and 82, in Ursa Major, which are as yet unresolved, but in the great Hercules cluster M 13, and surely indicates some difference from ordinary stellar light. And again, as a fresh point of resemblance in general unlikeness, M 13, as well as our two nebulæ in Andromeda, is said by Huggins to have its continuous spectrum crossed either by lines of absorption or bright lines. So strange did this appear to that great observer, that he was inclined to think in 1866 that perhaps the bright points in some clusters might not be of the same nature with true stars. At any rate the mystery, so far from being solved, seems only to be removed to a more inaccessible distance. What is that at which we gaze, overspreading field after field of the telescope with soft yet often vivid light? If gaseous, gas unknown, or in some hitherto unknown condition, or as Newcomb remarks, under an unintelligible amount of pressure. If stellar, how are its components so concealed, that neither in its extreme brightness, surpassing much, as I have especially noted, the great Orion nebula, nor in the evanescent faintness of its wide diffusion can they be insulated? If stars are there, they must be numbered by hundreds of thousands; yet possibly of much lesser magnitude than we, from ancient habit, are apt unconsciously to associate with the idea of a star. The examination, at least, of many globular clusters, has swept away old notions of size as well as distance; and there is no reason why bodies should not exist, not larger than the planets of our system, but emitting unborrowed light. And if such speculations may seem improbable, we may bear in mind that in venturing into these abysses, we have intruded into a strange and mysterious region, where probability is left behind, and we have to deal with possibilities alone.

What, again, are those rifts which seemed so strange to Sir John Herschel that he suggested the idea of the interposition of some less transparent material? Openings, perhaps, and indicating thinness of substance in the line of vision; openings which our earth, with its orbital velocity of 66,000 miles an hour, might possibly take years, possibly centuries, in crossing merely from side to side. This, however, must be observed, that they are not unparalleled in

* It is very remarkable that the usually accurate Humboldt should have so misapprehended Bond's meaning as to consider the fifteen hundred stars scattered over the nebulous area as a proof of the resolution which he expressly disclaims.

† A similar appearance is so often ascribed in those beautiful observations to the centers of nebulæ, as to induce a suspicion of peculiarity, either of vision or of structure; in the latter case, worthy of future attention.

other nebulæ.* But what, in any case, could be their origin? And how far are they shown to be unalterable?

And in the last place, what is the distance or real magnitude of that luminous mass? Is it on this or the other side of the stars so profusely scattered throughout the same visible area? It may be nearer, or, more correctly speaking, less unimaginably distant, than we are apt to suppose. It might even show sensible parallax. If d'Arrest's stellar point in 117 could be compared in position with neighboring stars; and even so, an enormous extent must still be assigned to it. Or it may lie yet further away in the unfathomable depths of space, expanded to a gigantic size—the largest body in the visible universe—the greatest display as to magnitude of its incomprehensible Creator.

And with these inquiries as to a mystery never, in all probability, to be penetrated by man, our imperfect remarks shall close. T. W. WEBB.

THE BARKING TOAD.

THE Zoological Society's insect-house during the past summer has been partially devoted during the winter months to the use of small reptiles and batrachians, for which they seem to be in every respect well adapted. Most of these animals, although shy and retiring in their habits, enjoy the warmth of the sun's rays and thrive excellently in their new habitations.

Among the batrachians thus exhibited are several species of gigantic size when compared with their puny representatives in this country, such as the Agua Toad (*Bufo agua*) of Brazil and the Ocellated Bladder-Frog (*Cystignathus ocellatus*) of Buenos Ayres. But by far the most remarkable of these forms in the series is the Adorned Ceratophrys, or "Esquerzo" of the natives of the Argentine Republic—a large toad of brilliant colors and extraordinary form, of which a figure is now given, taken from a water-color sketch prepared by Mr. Ernest Griset.

The Esquerzo was discovered by Mr. Darwin during the celebrated voyage of H.M.S. Beagle, and first described by the late Prof. Bell in the "Zoology of the Voyage of the Beagle." This monster inhabits the pampas of Buenos Ayres, and is said to feed chiefly on its smaller brethren of the same class. Mr. Ernest William White, F.Z.S., to whom the society is indebted for one of the two specimens now in the Gardens, specially mentions it in his lately-published "Cameos from the Silver-Land" as one

THE ESQUERZO, OR BARKING TOAD.

of the characteristic forms of the grassy plains of the Argentine Republic. "In the damp grass," he says, may often be perceived the leering eyes and mottled black and green body of the huge Esquerzo (*Ceratophrys ornata*), whose gaping mouth crammed with the body of an unfortunate sapo (toad), and surmounted by threatening horns, inspires terror. This said Esquerzo bears an awfully spiteful character, and is credited with the deaths of many children. His appearance is certainly against him, but he is otherwise perfectly harmless."

The Esquerzo seems to thrive equally well on English frogs as on the toads of Buenos Ayres, and does well in captivity. It is not, however, a very good object of exhibition, as, if left to its own devices, it hollows out a cavity to fit its body into the turf with which it is supplied, and leaves only the top of its head and projecting eyebrows barely visible. If harried out of its retreat for the examination of some curious visitor, it expands its body into almost a circular shape, and bites fiercely at any small object presented to it. At the same time it gives vent to its injured feelings in an angry whine, something like the snarl of a puppy, which has caused it to be known amongst the frequenters of the gardens as the "Barking Toad."—*Nature.*

ABSORPTION OF LIGHT IN THE ATMOSPHERE.

THE blue color of the atmosphere on a cloudless day has, like very many of the other very familiar phenomena which nature presents to us, been for a long time the subject of scientific investigation by physicists, and the enigma of meteorologists; and many speculations have been advanced respecting the cause, not only of the blueness of the sky, but also of the bluish haze which appears to veil dark shadows and distant objects.

Originally it was supposed that this tint was caused by the presence of exceedingly minute particles floating in the upper atmosphere, rendering it turbid, and reflecting chiefly the rays of smallest wave length, owing to their very minute size. Nor is this theory without foundation, for many similar phenomena are known to be produced by matter in a finely divided state. Professor Tyndall has performed many experiments, showing the action of vapors on light; and, by passing a beam of light through tubes containing air mixed with various organic vapors, he was able to produce artificial blue clouds. As the result of his experiments, he concluded that the blue color of the sky was due to the existence in the higher regions of the atmosphere of excessively fine particles of water or of some other substance, so finely divided, indeed, that their wave-lengths form but a small fraction of the length of a wave of violet light. This theory is strengthened also by the fact that both the light emitted from his artificial blue cloud, as well as that from a blue sky, is polarized in a direction at right angles to the axis of the rays.

More recent researches, however, have thrown additional light upon this subject, and have led to the idea that the cause of the blueness of the atmosphere is to be found in the absorptive power of ozone. Nor can we deny the fact that it is extremely difficult to believe that the extraordinary transparency of the distance, on many occasions when the sky is bluest, could exist when the air is filled with innumerable particles of solid matter, however small they might be; for in that case we should expect increase of blueness to be accompanied by greater haziness of the atmosphere.

At no very remote period it was doubted whether ozone existed in the atmosphere at all; for, unfortunately, the tests for its presence are ambiguous unless applied with the greatest care. But, although our knowledge of its actual amount and variation is still far from being perfect, recent researches prove conclusively not only that ozone is present in the atmosphere, but also that it plays a very important part in the absorption of solar rays.

It is found that a column of air a square centimeter in section acquires a full sky-blue tint from the presence of only 2·5 milligrammes of ozone, and a very considerable quantity of air assumes a blue color even when not more than about one seven-hundred-thousandths of its volume of ozone is present. Now this amount has been determined by Houzeau to be present under ordinary circumstances in the atmosphere. Hence it is extremely possible that ozone may be the cause of the blueness of the sky.

It has been shown by Hartley, who recently contributed to our columns the account of some interesting photo-spectroscopic observations, that if the absorptive power of gases and vapors causes this color in the atmosphere, the other constituents of the air cannot play any important part in the phenomenon; for ammonia, water vapor, and carbonic acid are all perfectly diactinic, even in considerable quantities. The only other substance capable of absorption of solar rays would be the oxides of nitrogen; but Hartley shows conclusively that it is impossible for these substances to have much effect in this respect; for if present, these substances would probably exist in the atmosphere as nitrate and nitrite of ammonium, which in minute quantities he found to be quite diactinic. Even if present in a free state in sufficient quantities to absorb the visible rays, the sky would not be blue at all; for photographs of the spectrum, transmitted by the oxides of nitrogen, show that these gases absorb just those rays which ozone transmits.

Now it is without doubt that the solar spectrum, as transmitted by ordinary air, is limited by the absorptive power of some constituent of the atmosphere, nor is this constituent invariably present in the same proportions; for Cornu has shown that the limit of the spectrum varies considerably with different meteorological conditions, the actinic rays being transmitted in greatest quantity at noon and at high elevations.

These facts, coupled with the extraordinary power which ozone possesses of absorbing the ultra violet rays, seem to prove beyond doubt that Hartley's views are correct, and that the ozone present in the atmosphere causes the limitation of the solar spectrum.

Thus the amount of ozone present in the air acquires a peculiar interest to photographers, by directly influencing the actinism of the sun's rays. Unfortunately, however, it is extremely difficult to determine with accuracy the variations which it undergoes. In the opinion of some chemists the proportion of ozone in the air is constant; but the experiments of Houzeau and Reiset seem to prove that it increases in quantity at high elevations and with the prevalence of southwest winds. Nor is it probable that its amount depends entirely upon the electrical conditions of the atmosphere, for it is produced in considerable quantities during the evaporation of water, and is probably derived from this source rather than from aerial discharges of electricity. Its absence from the air above great towns is explained by the fact that it is reduced by organic matter and sulphurous acid to the state of ordinary oxygen; but probably the ozone in the higher regions of the atmosphere would remain unaffected.

At a recent Thursday evening meeting the question was discussed, whether fog in the atmosphere cuts off the actinic rays of light in the same proportion as it does the luminous rays. The opinion was, that on account of the absorption of actinic rays by the yellow colors of the fog, the more refrangible rays were cut off in even larger proportion than the luminous rays. It is well known that smoke and volatile hydrocarbons are quite capable of extraordinary actinic absorption. In the opinion of Professor Hartley the presence of dust, such as carbon or finely divided opaque matter, has no other effect than to intercept the light and to weaken the whole spectrum; but the presence of even a minute quantity of benzine or naphthalene is to cut completely out a portion of the spectrum, so that no increase in the length of exposure would supply the missing rays.

It is gratifying to learn, however, that in most cases absorption does not increase in proportion to the quantity of the absorbing body present, but that generally a maximum effect is produced, beyond which any additional increase is without any appreciable effect. But it is without doubt that very large numbers of the imperfections in negatives produced by errors of exposure, on days when the conditions of light were apparently well understood, have their origin in the atmospheric absorption of actinic rays. In all cases photographers should guard themselves against the fallacy that a clear sky is necessarily accompanied by the maximum actinism of light.—*Phot. News.*

* Gen. Cat., 3,106 (Com. Ber.); 3,122 (Virgo); 3,501 (Cape Obs.), perhaps 4,698 (Aquar. Gaiesome). The first of these I have seen well with my nine and one-thirdinch speculum.

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